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Utilization and Commercialization of United Nations System-funded R and D Results

Case Studies on the Indian Experience

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UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

UTILIZATION AND COMMERCIALIZATION OF UNITED NATIONS SYSTEM-FUNDED R AND D RESULTS

A report by the UNCTAD secretariat
in co-operation with Mr. Rajiv Kumar

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Abbreviations

ATIRA	Ahmedabad Textile Industries Research Association
BRDC	Bicycle Research and Development Centre
CEERI	Central Electronics and Engineering Research Institute
CLRI	Central Leather Research Institute
COSTED	Committee on Science and Technology in Developing Countries
CP III	Third Country Programme (1985-1989)
CP IV	Fourth Country Programme (1990-1995)
CSIR	Council for Scientific and Industrial Research
CSMRS	Central Soil and Material Research Station
CWPRS	Central Water and Power Research Station
DST	Department of Science and Technology
DSIR	Department of Scientific and Industrial Research
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
FAO	Food and Agricultural Organization of the United Nations
GSI	Geological Survey of India
IDDC	Instruments Design Development and Facilities Centre
IDEMI	Institute for Design of Electrical Measuring Instruments
NGRI	National Geological Research Institute
NRDC	National Research Development Corporation
R and D	Research and Development
RRL	Regional Research Laboratory
SIIL	Sponge Iron India Ltd.
SWDC	Sheep and Wool Development Centre
UNDP	United Nations Development Progrmme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
WRI	Welding Research Institute

Foreword

(i) In paragraph 3 of resolution 308(XXX), the Trade and Development Board requested UNCTAD's Advisory Service on Transfer of Technology to provide assistance to developing countries for "the improvement of their access to, and use of, results from United Nations system-funded research development". The present report has been prepared pursuant to the above request. It is based on field research in India, where specific United Nations-funded projects embodying evident R and D components were identified through the review of a large amount of material available in the UNDP Office at New Delhi.

(ii) The UNCTAD secretariat is grateful to the UNDP office for support given to this work, thus facilitating the collection of information and data available from their office. Valuable comments were also received from Mr. Hamdy, the Resident Representative. The secretariat extends its thanks to the various government authorities, science and technology organizations and R and D institutions for their help in assembling information for the preparation of this report.

(iii) The present report is divided into three chapters. The first chapter seeks to define the scope and evolve an analytical framework within which to address the issue of commercialization of R and D results. This is done on the assumption that different types of R and D activity have varying potential for commercialization/utilization of their results; to this end, a typology of the R and D activity is drawn up. This chapter also describes the development and present stage of the Indian R and D network, the nature and scope of the United Nations system's role in it, and the methodology used for conducting the preparation of the report. The second chapter provides a synthesis of the information collected through the field work and the rationale for the sample of organizations selected for field visits. It provides 13 case studies of institutions and projects selected for detailed enquiry, in order to highlight some of the institutional features which may contribute to the relative success achieved in commercialization. The third chapter details the lessons drawn from the Indian experience. Although general in nature, the lessons are related to specific experience in individual R and D organizations - a fact which is emphasized in the chapter. This chapter ends with a brief summary of the report's major findings and conclusions regarding the modalities for commercialization.

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Chapter I

Scope and methodology

The nature of projects as well as the R and D activities undertaken, funded, or supported by the United Nations system vary widely. This has important implications regarding the potential utilization and commercialization of United Nations system-funded R and D results. In fact, the R and D activities supported by the United Nations system cover a wide array of sectors and fields. The range extends from agriculture and industry to energy, and from health and services to infrastructural development. The United Nations system is involved in R and D capability-building and/or utilization of results emanating from R and D activities. Depending on the nature of projects and on R and D activities, there are different ways and means for commercializing or utilizing technologies generated through R and D-related activities. The main purpose of this report is to identify precisely the modalities and examine those which could improve the commercialization and utilization of results and services generated through R and D activities funded by United Nations system projects.

A. Towards an analytical framework

The potential for utilization and commercialization of R and D results is obviously related to the nature of R and D activity which would be useful for effectively analyzing the potential for, and problems in, commercializing the results of R and D projects funded by the United Nations system.[1] Each category of R and D activity raises distinct issues. Different modalities may be required for maximizing economic and social gains from such activity. For the purpose of evolving a working typology of R and D activities, projects could be broadly classified into three categories: science-intensive R and D activities, adaptive or factor-substitutive R and D activities and production-related R and D activities.

1. Science-intensive R and D activities

The first broad category involves science-intensive R and D activities which are not synonymous with fundamental and basic scientific research. These R and D activities are directed at the public interest and societal needs which could not, or would not, otherwise be satisfied. While fundamental R and D is undertaken with a view to break-through, state-of-the-art technology, or to the opening up of new frontiers in science and technology (high technology), the science-intensive R and D predominantly encourages the transfer and adaptation of the state-of-the-art technology (sophisticated technology).[2]

With respect to commercialization, it should be pointed out that the uncertainty attached to the possible applicability of the outputs of fundamental R and D is qualitatively lower than in the case of science-intensive R and D projects. Furthermore, in a large majority of cases in India, and even more so perhaps in the case of other developing countries, United Nations' funds are directed towards science-intensive R and D activities.

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1 United Nations funds allocated for R and D projects can easily be seen as multilateral public funds which share characteristics similar to public funds in any individual member country.

2 For detailed discussion, see the communication from the Resident Representative of UNDP at New Delhi (Mr. Hamdy) to Assistant Administrator, UNDP, Ref. 2069 (cont.) dated 17 February 1989; see also *Trade and Development Report 1987*, second part, chapter V.

2. Adaptive or factor-substitutive R and D activities

This second category of R and D activities includes those undertaken for product adaptation or factor substitution. It emerges as a result of technology imports by firms in developing countries. In this case, R and D is directed towards bringing about necessary modifications in imported products and processes. Modifications are required in order to adapt the products and processes to consumer incomes, operational conditions and the prevailing factor prices in the host developing countries. It should be noted that this category of R and D may be undertaken by firms themselves, especially if they were reasonably sure of appropriating the benefits of the results. However, in most of the developing countries, individual firms do not perceive sufficient incentives to undertake the required factor-substituting type of R and D. Given their relatively weak financial position, investment in such R and D is often seen to be a non-optimal utilization of resources. Financial support and incentives in the form of tax credits, loans, grants and risk-sharing investment may therefore promote this type of R and D activity. Product-adaptive R and D is, on the other hand, undertaken predominantly by the firms themselves. A successful product-adaptive R and D programme generates results which can be more easily secured by the firms and which in any case provides some additional profits to them before its competitors are able successfully to "reverse engineer" the product and introduce the necessary changes in their products also. The scope of the adaptive or factor-substitutive R and D includes technologies related to the efficient use of resources, or wider use of raw materials, testing and quality controls to suit local capacity or requirements. United Nations' funds are directed to this category of R and D activity.

3. Production-related R and D activities

The third category comprises production-related (or shop-floor-related) R and D activities. These are directly user-oriented and user-defined activities. They often represent a formalization (or generalization) of 'learning' generated during production or other operations and functions.[3] In developing countries, a significant number of industries are dominated by enterprises that are small and medium-sized by international standards. These enterprises are unable to resolve some of their production-related problems owing to lack of technical expertise or the required equipment or both. Moreover, given their relatively weak technical base and resource constraints, they are unable to formalize, or generalize, any of the learning, which in some cases can be quite substantial. They cannot therefore convert any of the learning embodied in human capital into corporate or organizational know-how and thus suffer unduly from any turnover in skilled labour. In India, the Government has provided public funds and established autonomous R and D centres in an attempt to provide this input, as it is often critical for rapid growth of the small-sized enterprises sector. The United Nations system has supported this national endeavour and provided substantial financial support for establishing a number of such centres. Several of these production-supporting R and D centres have been established on the basis of initial grants received through the United Nations system.

The threefold classification of R and D activity and of executing agencies is useful, not only for analysing the structure of the Indian system of science and technology, but also so as to appreciate the role of the United Nations system in its evolution.

B. Indian science and technology system

The Indian science and technology system has evolved over the past four decades into an extremely complex network of government, quasi-government and autonomous agencies and organizations.[4] The major ministries/departments directly responsible for undertaking R and D ac-

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3 Normally, such R and D would constitute the very first stage of developing an in-house R and D facility within any firm in developed countries.

4 A glimpse of this complexity can be had by looking at the chapter on Science and Technology in the seventh five-year Plan document, pp. 352-381. A whole range of organizations, from private-sector-supported utilizations like Tata

tivities are the following: Department of Science and Technology; Department of Scientific and Industrial Research; Directorate of Technical Education (which funds the various technical institutions), Ministry of Human Resource Development (which through the University Grants Commission funds all R and D in universities), and the Department of Space and Atomic Energy Commission. Moreover, a large number of other government departments have extensive R and D facilities attached to them. The total capital outlay on science and technology schemes during the seventh five-year Plan was targetted to be 24,66 billion rupees ($US 1,644 million) which was more than double the outlay in the previous Plan. This figure did not include the outlay on R and D establishments attached to individual ministries/departments. The total outlay during the seventh Plan was slightly more than one per cent of the overall Plan outlay.[5]

Despite its complexity, the national system of science and technology in India (outside the corporate sector) could be seen to be comprised of three broad categories of R and D activities along lines similar to those discussed earlier. There is, however, a degree of overlap between the three categories. The basic and fundamental R and D activities supportive of high technologies were concentrated in a few autonomous R and D institutions and quasi-autonomous organizations under the departments of Space and Atomic Energy, such as the Indian Research Organization, Bhaba Atomic Research Centre, Centre for Advanced Technologies, *et al.* These two departments were together allocated 41 per cent of the total Plan outlay on science and technology during the seventh Plan. Another 22 per cent (5.8 billion rupees) was earmarked for R and D activities supported by the Department of Science and Technology and was destined for various R and D institutions and centres. This category of fundamental R and D is normally undertaken in universities in developed countries. In India too, as the Abid Hussain Committee pointed out, universities are expected to be the natural location for this type of research. However, given that most Indian universities "are still at a second remove from excellence in research" and are overburdened with teaching work, a substantial quantum of "basic research" has been shifted to the CSIR network of laboratories.[6] Thus, the figures mentioned above underestimate the share of Plan outlays which are actually devoted to basic R and D in high technologies in the Indian system of science and technology. This clearly reveals a strong bias in favour of basic research activities. In India, this bias has been recognized by the UNDP[7] which has to some extent recently endeavoured to tailor its own programme of research funding to complement the national efforts.

Factor-substitutive R and D activities are carried out predominantly in the network of laboratories established under the aegis of the Council for Scientific and Industrial Research (CSIR). The CSIR, established before independence in 1942, today has an extensive network of 39 research laboratories and over 100 extension centres and regional units spread throughout the country. Its scientific staff number around 5,600. They are supported by over 12,000 technical staff. CSIR's infrastructure has been built up over the years at a cost of 10 billion rupees. Its current annual budget is in the vicinity of 2 billion rupees. The functioning of the CSIR and other allied agencies is overseen by the Department of Scientific and Industrial Research which also monitors the progress of this type of factor-substitutive and product-adaptive R and D activities in the corporate sector. The seventh Plan had allocated a total of 3.35 billion rupees to the CSIR,[8] which was

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Institute of Fundamental Research, to autonomous universities and research centres such as the Indian Institute of Science, laboratories under the Council for Scientific and Industrial Research and R and D organizations attached to individual departments sectors as, for example, the Indian Council for Agricultural Research, make up this complex network. It should perhaps also be pointed out that this network exists within the government and the non-corporate sector. Another set of laboratories and research centres has been established as part of the corporate sector. They operate directly under the control of individual firms. As an example of this complexity, the seventh Plan mentioned that "A comprehensive and appropriate set of National Informational Systems would need to be evolved through the joint efforts of the Department of Electronics, DST, DSIR, CSIR, Department of Environment, Defence Research and Development Organization, ICAR, ICMR, Controller General of Patents, DGTD and various other organizations concerned with specific data base areas" (p. 366).

5 The Approach to the eighth five-year Plan (1990-1995) prepared by the previous Government had called for raising the share of Plan outlay on science and technology to 2 per cent of total Plan outlay.

6 See GOI, *Report of the CSIR Review Committee towards a new perspective*, New Delhi, December 1986, Chairman Shri Abid Hussain.

7 This recognition was explicitly revealed in a communication from UNDP's Resident Representative in New Delhi wherein it was stated, *inter alia*, that "India has a just and healthy aspiration in accelerating acquisition and development of high and sophisticated technology. It pursues this national goal with determination and an increasing sense of urgency and realism" (letter no. RR 2069, dated 17 February 1989).

8 Along with the CSIR, this category of R and D should also include the group of institutions and universities under

13.6 per cent of total outlay on science and technology. As pointed out above, some of these resources were siphoned off to "basic and high technology" R and D activities, undertaken within the CSIR network beyond its original charter. Hence, the Indian science and technology endeavour could be said to have given a relatively lower priority to directly commercializable and applicable R and D activity.

The third category of production-related R and D is undertaken largely in organizations attached to individual ministries and departments. Some examples are the Institute for Design of Electrical Measuring Instruments under the Department of Small-scale Industries; the Sheep and Wool Research Institute, attached to the Department of Agriculture and Rural Development in the state administration of Jammu and Kashmir, etc. A number of these institutions receive their capital and revenue from their respective ministries, and not from the budget allocation for science and technology. Mention should also be made of public-sector tool rooms, demonstration centres and a few production-related R and D institutions supported by a variety of sources (ministries, departments in both the central and state Governments).

C. United Nations system's role

In the recently concluded Third Country Programme (CP III - 1985-1989), the total outlay by the United Nations system on R and D projects in India was $US 146.57 million. CP III included 97 new project ideas, of which 69 had been approved as of 31 December 1988.[9] The United Nations system's contribution to each of these projects ranged from $US 400,000 to over $US 5 million. The average contribution was $US 1.5 million. The largest single group of 32 projects (30 per cent) involved contributions between $US 0.4 to 1.0 million, followed by another 31 projects whose outlay ranged between $US 1 to 2 million.[10] Another group of 16 projects (15 per cent) ranged between $US 2 and 5 million while three were over $US 5 million. The largest project, to which an outlay of $US 12 million had been committed, was in the area of agricultural education and research under the purview of the Indian Council of Agricultural Research. Finally, a group of 13 projects were allocated funds of less than $US 400,000. It is interesting to note that 30 per cent of the projects required an increase of less than 20 per cent at the time of mid-term project review, while four projects required an increase of 100 per cent.

The industrial sector had received 32 per cent of the total outlay. This sector was the largest recipient of the United Nations system's funds, at $US 47.8 million. This larger share to some extent compensated for the relatively lower priority given to this sector in the domestic Plan allocation for science and technology. Development of natural resources absorbed 19.6 per cent; agriculture came next with 15.1 per cent, then science and technology, with 14.8 per cent. Transport and communications were allocated $US 14.55 million, which was 9.9 per cent of the total outlay and six other sectors received less than 3 per cent of the CP III allocations.

An overwhelming majority of operational projects (projects started either under CP III or CP II) belongs to the category of institution-building. This classification, according to UNDP, implies the setting up of new institutional infrastructure or strengthening and improvement of the existing facilities. It is, however, difficult to categorize the projects themselves in terms of the threefold typology depicted in in the earlier chapter. This difficulty arises because United Nations sectoral outlays include projects which have widely varying components of high technology inputs and associated R and D activity. In some cases, and especially for larger projects, all three components of science-intensive, factor-substitutive and production-related R and D activities were included. Thus, UNDP's assistance for the agricultural sector was channelled through 18 projects with an average outlay of less than $US 1 million (one project of the 18 was assigned $US 11.78

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the Indian Council of Agricultural Research (ICAR) which was in its scope and nature of operations different from R and D facilities attached to individual ministries departments.

9 See UNDP, Office of the Resident Representative in India, *Assessment of prior UNDP experience in India* (May 1989), Part I, mimeo, New Delhi, pp. 14-16. See also UNDP, Office of the Resident Representative in India, *Background paper UNDP Third Country Programme review*, mimeo, New Delhi, 1989, pp. 24-25.

10 As the above cited document notes on p. 18, this outlay of $US 22 million to the agricultural sector and an average project allocation of $US 1 million, has implied that "....the support of UNDP has been utilized, especially for *catalytic purposes* with the bulk of resources for programme development coming from domestic resources".

million while the remaining 17 shared the residual of $US 11 million). A cursory scrutiny of all 18 projects, shows that at least three could be said to include science-intensive, or even basic R and D components.[11] Similarly, in industry, a total of 55 projects were allocated funds totalling $US 47.8 million under the CP III. Of these, at least eight had substantial high-technology inputs, such as in the projects on computer-aided design, semi-conductor devices, fibre optics, ceramic technologies, etc. The programme on science and technology comprising 17 projects had relatively greater degrees of high-technology inputs in each project. Similarly, each sectoral programme also had factor-substitutive and production-related projects as well. This is clearly evident from a perusal of the extensive review documentation prepared by UNDP on the performance of the CP III in India.

The role of the United Nations system's assistance hitherto in the development of the national R and D capability can best be described as catalytic in its nature and in terms of the quantum of its contribution. This role has obviously crystallized over the past three decades of the United Nations system's involvement in the Indian R and D effort, starting with the United Nations Expanded Programme of Technical Assistance (EPTA) during the 1950s. UNDP (which co-ordinates the activities and intervention of all United Nations system agencies, organs and bodies in individual countries) visualizes the objective of its assistance under the country programmes as "bridging the technology gaps in a wide range of activities". This objective had apparently emerged as early as 1972, when it was explicitly recognized both by the Indian Government as well as by the United Nations system that, given the almost unlimited technological needs of the country, and in the more limited context of even the overall size of India's own indigenous R and D effort, the United Nations system would play at best a catalytic role in this effort. The United Nations system's assistance has consequently been spread over a wide range of R and D activities.

In actual practice, over the years, the financial and institutional inputs of the United Nations system into India's R and D effort offer "....stimulus at a variety of growth points in the system and assume the function of a catalytic agent....".[12] Moreover, being completely untied, the United Nations system's assistance has been tailored, to the extent possible, to the country's self-determined priorities and pattern of development. The actual composition of the financial assistance received has also changed over the years in terms of share of outlays designated for foreign project management personnel, international experts, training of Indian personnel and laboratory equipment, etc. This change has been in line with India's growing capabilities in project management and technical skills and greater requirements for sophisticated scientific equipment to which the access of domestic R and D organizations is severely constrained because of resource scarcity. Thus, the projects increasingly have Indian nationals as project directors. Foreign chief technical advisers, where required, have been assigned for short periods at different stages of the project. Expenditure on equipment currently accounts for more than 50 per cent of total project outlay.[13]

The Indian science and technology system, and the United Nations system's role in it as described above, provides the necessary context in which to discuss the methodology and coverage of the field research undertaken as part of this study.

D. Methodology

Within the framework of this report, a large amount of material available in UNDP offices was initially reviewed in order to identify specific projects embodying evident R and D content. In close co-operation with the United Nations organizations concerned, existing material related to R and D activities was also reviewed, particularly projects and evaluations of projects com-

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[11] Examples of such R and D activities (high technology) inclusive of projects under CP III in the agricultural sector, were low-cost bio-fertilizer, agricultural education and research and plant improvement where some inputs of advanced genetic technology and research were envisaged.

[12] See UNDP, *Assessment of prior experience* (1989), p. 12.

[13] See UNDP, Office of the Resident Representative in India, *Proceedings, UNDP Third Country Programme Review Meeting*, mimeo, New Delhi, p. 17 (Address by Mr. Hamdy, Resident Representative).

pleted over the last 10 years. The universe of projects being vast, a sample covering a broad spectrum of possible results was chosen for more detailed analyses. From these some of the parameters, problems, or possible alternative solutions were expected to emerge, be identified or evolve. Field work was initiated with the co-operation of the UNDP Office in New Delhi, in order to follow up on the results of several R and D efforts upon completion of a project supported by the United Nations system, and to identify possible methods of facilitating wider diffusion of the benefits. Detailed checklists were also prepared in order to ensure that information collected would be comparable.

The collection of relevant data and information was mainly achieved by (a) extraction from available final project reports; and (b) interviews with government R and D institutions. Since final project reports have little to say directly about commercialization of R and D results, considerable importance was attached to interviews for learning what was happening in R and D institutions where United Nations system-funded projects have been implemented.

To this effect, a two-week field visit was undertaken as part of the study. The initial terms of reference envisaged examining 26 R and D projects funded by the United Nations system and the interviewing of relevant project personnel. This would have necessitated field visits to 19 research institutions where these projects has been undertaken; however, locationally they were very widely dispersed, making it unfeasible to cover them within the period of the designated field work. More importantly, from a detailed examination of the initially selected R and D projects, it became clear that some of these projects were part of larger, more comprehensive research programmes being undertaken at these institutions. Apart from individual projects mentioned in the original terms of reference, a number of other projects - also funded by the United Nations system - constituted these larger programmes. The success of any individual project, especially in terms of utilization of its results and/or facilities created, appeared to be often linked to the output of the other projects within the programme. Consequently, it was necessary to examine the programme as a whole. As a result, the actual field work concentrated on 13 (rather than 19) institutions where, however, 24 (compared to the originally envisaged 26) projects were examined. The focus on the 13 institutions finally examined facilitated the understanding of the institutional factors which contribute significantly to the successful utilization and commercialization of R and D results. This approach allowed the examination of the problems faced by these institutions in maintaining a continuity in their R and D activities and in usefully absorbing the project-specific funding by the United Nations agencies. The enquiry into interrelated projects permitted a better appreciation of the modalities through which institutions try to build upon existing facilities through, for example, successive projects, each of which is funded sometimes by different agencies, either within the United Nations system, or the domestic R and D establishment. These interrelated and successive projects such as, for example, those taken up successfully by the Central Water and Power Research Station (CWPRS), effectively reduce what may be referred to as the cost of commercial applications of R and D because they benefit from accumulated learning in the institutions. Moreover, each project adds incrementally to the existing hardware and equipment. This is more efficient than building up comparable capability in a new institution. The focus on the selected 13 organizations appears to have yielded interesting results.

Of the total number of R and D projects funded by the United Nations system in India, which have been examined as part of this study, 56 per cent were in the category of science-intensive R and D activity. Another 23 per cent were production-related R and D projects in support of small-scale enterprises. Some 21 per cent were in the category of product-adaptive or factor-substitutive R and D activity. In terms of shares in total financial allocation, distribution follows a somewhat corresponding pattern. The total financial commitment by the United Nations system for the projects which constitute the sample for this study amounts to SUS 34.21 million. This sum refers to the allocation actually made by the United Nations agencies, but does not necessarily include expenditures initially budgeted for the programmes. Of this total allocation, 69 per cent was committed to the science-intensive R and D activities; 24 per cent to the production-related; and 7 per cent to the product-adaptive or factor-substitutive R and D activities.

Clearly, while the present report has been able to identify certain aspects and factors which could be helpful in improving the understanding of the catalytic role played by United Nations system-funded R and D within the Indian science and technology set-up, and certain findings which could assist in improving the modalities for the commercialization of such R and D results, this effort cannot be considered complete. While the field research, for example, was able to con-

centrate on the projects themselves and the related institutional factors, it did not cover to the actual users of the R and D results generated by the institutions. On a number of occasions, personnel interviewed also emphasized the importance of questioning the users on the benefits they may have derived from commercial application of the R and D results supplied to them. This was especially true of the production-related activity of the R and D institutions mentioned in the previous paragraph. This gap should be covered in any future study aimed at improving the commercialization and utilization of United Nations-funded R and D results in developing countries.

Another important issue which could be discussed indepth relates to the legal aspects of commercialization and of acquisition of intellectual property rights over R and D results. In a few instances, this issue was raised by the R and D personnel of the institutions visited during the study. The division of responsibility for taking the necessary steps to commercialize the results and of ownership of any rights or pecuniary benefits which may accrue as a result was not clear at this stage. This question would need to be sorted out before practical steps are taken to improve commercialization of United Nations-funded R and D in the country.

Finally, the technical merits of some of the results could not be directly evaluated during this study. In some cases, the terminal reports for the project highlighted the technical results. Yet, in most cases, the actual worth of the project's results in terms of their potential in utilization or commercialization is only mentioned in a cursory fashion. Given the scope and coverage of the study, the sample of projects selected for detailed examination was obviously focused on projects which were completed or, at least, about to be completed. The next chapter provides details of the projects and institutions - case studies - with a view to establishing the context within which to derive lessons for commercialization and utilization of R and D results emanating from United Nations-funded projects.

Chapter II

Case studies

This chapter provides details of the United Nations system-funded projects divided into 13 case studies. The number corresponds to 13 institutions responsible for the projects' execution. These institutions, in relation to the nature of the R and D activities carried out in the projects examined, fall, in terms of the typology of R and D activities developed in chapter I, into three categories.

Four of these institutions were primarily engaged in *science-intensive research activity*: the Central Water and Power Research Station (CWPRS); the National Geological Research Institute (NGRI); the Central Electronics and Engineering Research Institute (CEERI); and the Central Soil and Material Research Station (CSMRS). All four institutions are in the public sector network of R and D and are financed primarily through government grants. Two of these institutions, the CEERI and the NGRI, are part of the chain of research institutions under the Council of Scientific and Industrial Research (CSIR). The other two are attached to the Ministry of Water Resources of the Government of India.

Four dealt with *the adaptive or factor-substitutive* type of R and D activities: Sponge Iron India Ltd. (SIIL); Regional Research Laboratory (RRL); Ahmedabad Textile Industries Research Association (ATIRA); and Central Leather Research Institute (CLRI). RRL and CLRI are part of the CSIR network and receive United Nations funds either for special projects, such as coal gasification, development of slaughterhouse by-products, or for importing the needed equipment for ongoing projects. SIIL was established with the help of UNIDO funds to improve and commercialize the technology to produce sponge iron by using non-coking coal as a reducing agent. Having successfully achieved this objective, it is now a commercial manufacturing operation which generates its own resources. ATIRA is an exception among this group of 13 institutions on account of having been established jointly by the private-sector textile manufacturers on which the institution continues to rely for part of its finances. ATIRA has close links with the industry and more than half of its recurring expenditure is financed through industry contribution.[14]

Five R and D institutions in the sample were principally engaged in providing *production-related* and supportive R and D activity to industrial units. They represent a wide range and level of R and D activity. These five are: Welding Research Institute (WRI); Sheep and Wool Development Centre (SWDC); Bicycle Research and Development Centre (BRDC); Instruments Design Development and Facilities Centre (IDDC); and Institute for Design of Electrical Measuring Instruments (IDEMI). The range of R and D activity extends from the agricultural sector, where SWDC is engaged in the development of new breeds of sheep and wool processing techniques, to IDDC and IDEMI, which develop simple electronic measuring instruments for their users and provide advanced machining and other industrial processes for small-scale enterprises in their region. WRI and BRDC operate in the metal-based engineering industries. The level of R and D activity undertaken in these five institutions is also significantly different. WRI develops new welding techniques and conducts advanced research into materials, welding electrodes, welding media and machines, etc. At the other extreme, SWDC also undertakes extension service among farmers encouraging them to propogate new breeds and try new techniques. BRDC, IDDC and IDEMI also predominantly undertake development and problem-resolving kinds of activities.[15]

In reviewing the case studies presented below, one may note that each case has its own unique set of variables in relation to better utilization and commercialization of its R and D-related activities. However, there are common conditions and modalities which can be identified

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[14] As is discussed later in the study, these forms of budgetary support and the nature of R and D institutions' links with the industry partially determine the success in commercialization/utilization of results.

[15] Some basic research, especially on chemical properties of textile fibres, is also undertaken at ATIRA.

as having important implications for ensuring effective utilization or commercialization. The questions are treated in the next chapter.

Case no. 1:

Central Water and Power Research Station (CWPRS)

(a) Projects examined:

(i)	IND/71/601:	Coastal Engineering Research Centre and Development of Hydraulic Instrumentation
(ii)	IND/75/020:	Extension of Hydraulic Instrumentation Centre
(iii)	IND/73/043:	Coastal Engineering Research Centre (extension)
(iv)	IND/73/041:	Applied Earth Science Division
(v)	IND/81/038:	Hydraulic Structure Research Centre
(vi)	IND/73/042:	Hydromechanics Division
(vii)	IND/85/069:	Extension of Hydromechanics Division (testing laboratories for submersible pumps and pumps used for thermal and nuclear power generation)

(b) Background

CWPRS has been a recipient of United Nations system assistance since 1950, when a grant of $US 80,000 was made to establish a Ship Model Testing Tank at CWPRS. The Station received two other grants during the 1950s and 1960s. One was used to set up a Photoelastic Laboratory (1956-57) for which UNDP provided $US 16,000. During 1962-68, a second grant was made amounting to $US 491,000 for establishing a Cavitation Research Centre.

During the 1970s and 1980s, CWPRS received United Nations assistance for seven projects. Details concerning the financial allocations for these seven projects, both from the United Nations and the Government of India are provided in table 1. The total assistance received from the United Nations system by CWPRS since its inception amounts $US 17,028,346, of which $US 16,441,346 were received for the seven projects undertaken during the last two decades. The counterpart funds made available by the Government of India for these seven projects have amounted to 63,118,473 rupees.

CWPRS has thus been one of the largest recipients in India of United Nations funds for the establishment of R and D facilities. It has interacted with the United Nations system of science, technology and industrial development for more than three and a half decades. As is to be expected, the Station, its activities and the role of United Nations support have been evaluated on more than one occasion. These evaluations have been comprehensive in nature and supplement those undertaken for individual projects. These evaluation reports, prepared by international and national experts, provide a mine of information as well as recommendations which, apart from being applicable to CWPRS, have also general relevance. The first such evaluation was undertaken by a High Level Committee, headed by Dr. A.S. Swaminathan, and was completed in 1977. Recently, CWPRS activities were evaluated by a Joint Evaluation Committee comprising both Indian and international experts. This Committee, which included three international consultants, namely, Messrs. Ernest Pareset, Maurice Albertson and Kenneth Medearis, submitted its report in January 1985. These reports, supplemented by discussions at CWPRS, are the basis of the present report.

The Station was founded in 1916 to serve the needs of the Bombay Presidency. It was taken over by the central Government in 1937. In 1971, CWPRS was recognized by the United Nations as the Regional Hydraulic Laboratory for ESCAP. It has an approved staff strength of 2000, of which more than 400 are highly experienced engineers and scientists. Its field of activities covers river engineering, coastal and off-shore engineering, geotechniques, hydraulic machinery, structures, development of instrumentation, collection of field data, ship hydro-dynamics and mathematical modelling. It also possesses one of the largest and most powerful computer systems in the country. It is considered "by far the best and largest research station in its field in the region. The Station is currently tackling more than 400 problems under different projects. Its expertise has also been made available to more than a dozen developing countries in Africa and Asia.

The Research Station caters for the needs of sectoral projects, particularly irrigation, power and transport. In addition, CWPRS facilities are utilized by heavy industry (both in the public and private sectors) with respect to such problems as foundations and discharge of effluents; in the road and railways sector, it pursues optimal designs of bridges; the petroleum companies consult it for off-shore exploration, etc. The three primary client sectors (irrigation, power and transport) account for more than one-third to half of total investment outlays in the various plans. Major disciplines at the centres relate to: (i) river and canal hydraulics; (ii) reservoir and appurtenant structures; (iii) coastal and off-shore engineering; (iv) hydraulic machinery; (v) stratified flow; (vi) structural modelling; (vii) mathematical modelling; (viii) applied earth sciences; (ix) instrumentation and data acquisition; (x) ship hydro-dynamics, and (xi) support services.

The Station depends upon the Government of India's financial support for meeting part of its recurring expenditure. It is to the credit of the Station that it generates sufficient revenue from its sponsored projects to meet 40 per cent of its annual revenue expenditure. Its capital expenditure on buildings, equipment and computers, etc., is financed predominantly by the grants received from the United Nations system and the Government of India under the projects enumerated earlier.

(c) Project results

The CWPRS has been one of the largest recipients of United Nations funds. Initially (i.e. in the 1950s and 1960s), the CWPRS relied predominantly upon technical assistance to acquire the equipment necessary for its laboratories. Over time, the nature of technical assistance changed, as the technological capabilities of the CWPRS were strengthened. Technical assistance funding is now used for acquiring highly sophisticated state-of-the-art equipment-embodied technology. This need for the latest equipment has been reinforced since the CWPRS emerged as the regional laboratory in the ESCAP region. The following overview of activities of the Institution delineates the areas to which the projects have contributed.

With its *ship testing tank*, it has, during its 26 years of existence contributed to the design testing of more than 180 ships and 86 propellers. Total foreign exchange *savings* estimated by CWPRS for these services have amounted to 48 million rupees. It has been reported that this facility needs further upgrading and scaling-up.

Mention should also be made of the *Photoelastic Laboratory* which has been reputed to have repaid its initial investment "many times over". One client was apparently so satisfied with its services that he donated $US 20,000 to the Station for the purchase of advanced equipment.

The activities of the *Cavitation Research Centre* (CRC) is geared towards its primary research facility: the water tunnel. This caters for industrial testing and development research on performance and cavitation characteristics of hydraulic machines and equipment. It also provides critical inputs for minimizing failure or damage caused by cavitation as a result of the working of hydraulic machines operating with high heads or at high speeds. CRC collaborates continuously with Bharath Heavy Electricals, the largest manufacturer of turbines in India. It also regularly serves the needs of private pump manufacturers such as Kirloskars, etc. Benefits from CRC are difficult to quantify, as they are essentially in terms of event-free maximum generation of power (turbine) and availability of irrigation and other water supplies (pumps). CRC's set-up is similar to Government laboratories in other countries. Given that its operations are non-profit making

and of a fundamental rather than end-use or commercial nature, an evaluation of benefits is difficult to make.

Another of its centres, the *Coastal Engineering Research Centre* (CERC) has played an important role in the development of ports and harbours in the country. With the acquisition of sophisticated equipment, the CERC has started to extend its services to the ESCAP region. This is demonstrated by the design work undertaken by CERC for the port authority of Singapore and similar jobs in Sri Lanka, Myanmar, Indonesia and the Philippines. It is estimated that annual savings (i.e. the amount that would have been spent by clients in foreign exchange for similar services) generated by CERC has amounted to 120 million rupees. Total investment in the initial and extension phases has been 20 million rupees. UNDP support to CERC may be said to have been highly beneficial.

In the area of instrumentation, the *Hydraulic Instrumentation Centre* has a total investment of 22 million rupees. It acts as a service division for all other laboratories in the Station. This Centre also caters for the needs of field data collection by designing and developing specific instruments required for working under particular local conditions. Benefits from the Centre are difficult to quantify; CWPRS, however, claims that the benefits to cost ratio have been in the order of 100 to 1 for this project, as with others in the Station.

The activities of the *Applied Earth Sciences Division* are related to iso hydrology, hydro geology and vibration technology. Capital outlay, inclusive of Government of India funds, is 12 million rupees, while the project is expected to yield benefits of 48 million rupees annually.

Activities of the *Hydromechanics Division* are related to improvements in operational efficiency of large capacity pumps. These are used for lift irrigation and water-supply schemes and in cooling systems of thermal and atomic power plants. For example, a 1 per cent improvement in pump efficiency was reported to have yielded annual savings of 0.12 million rupees in the Bikaner lift irrigation scheme. Twelve million rupees have been invested in this facility. It also serves the testing requirements of a large number of pump manufacturers in the country. With 500,000 pumps of various capacities being manufactured in the country, and a number of irrigation and power generation schemes in the offing, it is expected that through this Division's work substantial savings will be generated not only in the capital cost of manufacturing pumps, but also in their running costs.

Mention should also be made of a project related to the *Hydraulic Structures Research Centre*, which has the largest planned capital outlay of 58 million rupees, inclusive of United Nations system and Government of India contributions. The project aims at the building up of scientific and technological expertise in areas of hydraulic and structural model-based research on dams, power houses and allied structures. These facilities would permit integrated studies of both structural and hydraulic problems in sophisticated structures such as arch dams, bifurcations, pipeline supports, design and construction of hollow gravity dams, etc. Benefits are expected to be generated not only from savings in costs of construction but also from financial benefits accruing owing to power and irrigation potential. The project, as submitted to UNDP and as being implemented, has three components dealing with hydraulic, structural and mathematical aspects. The expected benefit to cost ratio is in excess of 100 per cent. The estimated benefit to the water resources sector as a result of the CSMRS activities and, in particular, its contribution to geomechanical and research investigations is shown in annex I to this report (table 2). The annex includes a list of projects carried out in other developing countries in the water resources sector by the Station (table 3).

Case no. 2:

Sponge Iron India Limited (SIIL)
(Hyderabad)

(a) Project: IND/81/004

Title:	Standardization of Melting Technology for Sponge Iron
Executing agency:	UNIDO
Commencement date:	June 1981
Duration:	
Initial:	12 months, up to May 1982
Extension:	3 years, May 1985
UNDP grant:	
Initial:	SUS 398,550
Revised:	SUS 399,016
Government of India grant:	1,560,000 rupees (in kind)

(b) Background

The general objective was to increase steel production of mini-steel plants in India, using sponge iron instead of imported steel scrap, and to develop self-reliance in this field. At present, the bulk of sponge iron technology around the world is based on natural gas. The latter is used both in making iron pellets, which go into making sponge iron, and in melting sponge iron for making steel. Sponge iron made from natural gas is highly reactive and requires special techniques in storage and handling. On account of the above, a demonstration sponge iron plant was set up in Kothagundem with United Nations system assistance.

The demonstration plant, which is in continuous operation, provides valuable technical information for design and operation of future commercial plants. Its further application under Indian conditions has been developed. This effort is noteworthy because sponge iron is made from Indian iron ore, which has a high phosphorous content, and with non-coking coal. As such, special techniques had to be developed for feeding, melting, handling, storage and transportation of sponge iron under local conditions.

The main objectives of this project were to establish melting practices of sponge iron in electric arc furnaces and to formulate the optimum scrap-sponge iron ratio and optimum metallization of sponge iron for conversion into steel under Indian conditions, and to evolve methods of storage, handling and transport of sponge iron under Indian conditions, especially so as to avoid self-ignition. The project has also included activities such as the design of equipment for continuous charging of sponge iron into electric furnaces and to undertake detailed engineering of the same and the feasibility of a continuous hot charging method for feeding sponge iron into the electric furnaces.

(c) Project results

SIIL successfully prepared the basic engineering and design for continuous charging equipment for feeding sponge iron into two furnaces, namely, M/S A.P. Steel Limited, Paloncha (AP) and M/S Tamil Nadu Steels Limited at Arakkonam (near Madras). These were installed and

commissioned and, although the latter had to be shut down later owing to a severe power shortage, the trial runs on both showed that the process used less power as compared to the batch charging technique; 50 per cent of sponge iron could be effectively used as compared to 25 per cent with the earlier techniques. Furthermore, there was a higher liquid steel yield and an increase of approximately 5 per cent in productivity. Technical reports were prepared on the basis of this experience and were made available to steel plants, a number of which procured their sponge iron from the demonstration plant. Progress was also made in the areas of storage, handling and transportation of the sponge iron. A new process was evolved for making briquettes from the fines which were thrown out during the production of sponge iron. Fines, presently dumped as waste products, could if used in the form of briquettes, increase the availability of sponge iron by at least 10 to 15 per cent. The continuous hot charging technique could not be successfully evolved. In view of the power shortage faced by a large number of steel plants in the country and the shortage of steel scrap, the project, by evolving processes which use less power and which reduce dependence on local and imported steel scrap, can be said to have been successful in achieving its objectives.

As a result of this project, some commercialization output has emerged in terms of a more power- and product-efficient technique in the process of making steel from sponge iron, as well as in terms of detailed designing and engineering of continuous charging equipment for feeding sponge iron into arc furnaces.

Some progress has been made in promoting technology development and technology transfer in the area of sponge iron manufacture to countries in the ESCAP region through provision of technical services in testing the suitability of raw materials for the production of sponge iron.

Case no. 3:

National Geological Research Institute (NGRI)
(Hyderabad)

(a) Project: IND/79/047

Title:	Integrated Exploration Methods for Minerals
Executing agency:	United Nations Office for Project Execution
UNDP grant:	$US 510,900 (originally allocated) $US 754,589 (revised and actual)
Government of India grant:	4,263,330 rupees
Completion date:	June 1985
Extended to:	December 1986

(b) Background

This project succeeded an earlier UNDP-sponsored project undertaken by NGRI. The earlier project, entitled "Techniques for exploration of mineral resources" (IND/74/012), had been completed in 1981. During the course of the earlier project, NGRI had successfully developed some computer-based equipment utilized in geological exploration. Further, some useful computer software, which permitted faster processing and interpretation of survey data, had also been developed.

The Institute had already in 1979 proposed to the Government of India a further project which would enable NGRI scientists to test the performance of the equipment developed and acquired during the course of project IND/74/012, and to undertake integrated field studies and an

exploration programme for analysis and interpretation of data relating to an identifiable geological feature in Andhra Pradesh. The latter project is in many ways a sequel to the earlier one.

NGRI was set up as one of the national laboratories within the public-sector system of science and technology which has evolved under the aegis of CSIR. The Institute was established in 1961. Its charter of functions includes the development of methods and tools for the exploration of groundwater and minerals. As a result, development of geological instruments and of techniques to interpret geological data is an ongoing activity at NGRI. It works in close co-ordination with the Geological Survey of India, which is a field organization, and with other research institutions both within and outside the country. NGRI has a strong research faculty.

The development objective of the project was to provide better field-survey procedures, instrumentation, interpretation and analysis facilities in the search for minerals and groundwater by geological surveys. Instruments and techniques developed by NGRI, it was hoped, would be commonly used by other survey organizations in subsequent years. The project was consequently expected to evaluate the performance of equipment developed earlier at NGRI, modify it wherever necessary, and develop advanced software for it. NGRI was also expected to disseminate the results as widely as possible so as to ensure fuller application of advanced geological technology.

(c) Project results

The two most important outputs of the project were first to test fully the GS-100 - a geological microprocessor-based-time-domain EM instrument which provides superior signals through noise rejection for detection of mineral deposits. This was developed during the previous project. During IND/79/047, a prototype of the equipment was initially developed and field-tested. Subsequently, four of these instruments were put together at NGRI for its own use and also supplied to GSI. During field trials on over 240 square kilometres of covered ground, it was demonstrated that the GS-100 was superior to existing (older style) imported time-domain EM devices - the Crone PEM. The equipment greatly contributed to NGRI's success in locating vast reserves of kimberlite, some of which is also diamond-bearing. Properly pursued, this device should lead to greater discoveries. The project also envisaged the drawing up of a detailed geological map of the Cuddapah Basin. For this purpose, the NGRI received a VAX-11/750 computer which qualitatively improved computer facilities at the Institute. As a result, a new phase of computer-related research activity has started in NGRI. With the help of the VAX computer, an elaborate exercise in the synthesis of information of different types was undertaken to bring out unknown details in the geology of the Cuddapah basin. A fine set of software has also been developed.

The only shortfall in the achievement of expected objectives has been in relation to the acquisition and use of an airborne doppler navigation system. The NGRI scientist was trained abroad and the navigation system was imported. To begin with, the system was found to be malfunctioning and, more unfortunately, the only NGRI trained scientist who was able to use it passed away. This shortfall, however, did not affect any other segments of the project.

The utilization of project results has been varied in nature. The Geological Survey of India (GSI), after receiving four GS-100 instruments and certifying their performance as good, did not show further interest. This was because foreign aid received for procurement of survey equipment restricted GSI to particular sources. The bore hole logger was fully developed to its prototype version. Owing to lack of response from potential users and flagging academic interest on the part of the NGRI scientists, further development has stopped.

In both cases cited, NGRI had firm offers from private- and public-sector manufacturers to take up commercial production of the instruments developed. NGRI was, however, advised against patenting these instruments and likewise against charging licence fees to possible manufacturers. In the absence of any incentive to commercialize these results, NGRI staff lost interest and let the production be confined to workshop activity at NGRI. Meanwhile, a number of firms have developed similar instruments based on NGRI concepts, and these have captured the international markets. Moreover, a number of NGRI scientists have themselves left the Institute and set up independent production facilities. Others have joined private companies and even multinationals where they find better commercialization potential for their research. Despite these set-

backs, NGRI has still managed to sell more than two dozen of its EM units and has thus recovered their costs. Its system of analysis of stream sediment samples utilized for Kimberlite detection has general applicability for other minerals such as gold, and it is already being applied. The software developed by it has become part of an NGRI software library accessible to other users, and some of its software has been utilized by the Geological Survey of India (GSI). Although NGRI could not commercially transfer the know-how for its bore hole logger, it has built a few units and supplied them to actual users. Shallow EM units have been fabricated for the revenue services for metal detection at Customs. Finally, its multifrequency Turam apparatus, after some engineering modifications, is being successfully utilized.

The two projects at NGRI represent a successful undertaking of applied R and D work. Its inability to commercialize fully the results is an important lesson to be kept in mind in future attempts to commercialize United Nations-funded R and D results.

Case no. 4:

Welding Research Institute (WRI)
(Tiruchirapalli)

(a) Project: IND/79/026

Title:	Welding Research Institute - Phase II
Awarded to:	Welding Research Institute (Tiruchirapalli) Bharat Heavy Electricals Ltd.
Executing agency:	UNIDO
Commencement date:	October 1980
Duration:	3 years
Extension:	1 year, 3 months
Completion date:	December 1984
UNDP grant:	
Initial:	SUS 2.185 million
Revised:	SUS 2.58 million
Government of India grant:	104,620,000 rupees (in kind)

(b) Background

Welding is a production technology that plays an important role in almost every manufacturing and fabrication industry. Recognizing the need to develop welding as a discipline, the Government of India set up a National Welding Research Institute in 1975. In order to ensure a close link between such an institute and industry, so as to cater for the needs and problems of the latter, the Institute was set up under the aegis of Bharat Heavy Electricals Limited, Tiruchirapalli, a large public-sector undertaking. United Nations system assistance was sought initially for financing the importation of equipment, the training of Institute personnel abroad, and deputation of experts to the Institute. SUS 2.02 million was granted for phase I of the project. In this phase, it was intended that the project successfully create a technical information and documentation section, organize workshops and seminars, provide short-term courses and package programmes in its training school, establish strong links with industry through its consulting and quality-control services and undertake sponsored research - all of which was indeed accomplished.

Although the major objectives of phase I were achieved, the Institute could not make adequate progress in the area of consumable development, understood as the improvement of the quality of indigenous manufactured consumables (electrodes to cater to the varied need of manufacturing industries or welding flux). Phase II of the project was then proposed to supplement the earlier phase. A pilot plant was thus set up for consumable development, with advanced welding and testing systems, in order to make the Institute a full-fledged research organization. The project's main objectives were to tackle the practical problems of Indian welding industries and to set up a pilot-plant facility for development, foundation and production of filler materials and fluxes so as to improve the quality of indigenously manufactured consumables and provide new filler materials increasingly demanded by industry.

(c) Project results

In the area of *consumable development*, different electrodes were developed to cater for the varied needs of fabrication industries. Its special electrodes have been introduced into more than 150 system units throughout India. In addition, research and development activities in welding fluxes included the identification of 12 types of fluxes, of which four flux formulations have been developed and introduced in Indian industries.

In the area of *welding and testing*, the Institute has developed a new technique (Narrow Gap Welding) to meet quality and cost requirements of producing heavy thickness pressure vessels for chemical and power industries. A prototype machine has been designed and developed.

The Institute has begun functioning as a national welding institute and is recognized as such by industry, with which it has established close links, providing it with quality control, testing, consultancy and training facilities. More importantly, it has begun successfully undertaking fundamental research, which has resulted in the registration of 15 patents on the development of 10 types of electrodes, including that of hard-facing electrodes which have found application in the Indian sugar industry where prospects for export orders are bright. With the completion of the formulation of four of the 12 fluxes identified, which would also find ready application in industry, the Institute has achieved another commercializable output. Moreover, it has designed and developed for demonstration a prototype machine for a new welding technique.

In other words, the R and D work of the Institute has led to innovation and adaptation and clearly commercializable output. The United Nations' role has been primarily in the provision of equipment for the Research Institute. The full commercial potential has, however, not been exploited so far.

Case no. 5:

Regional Research Laboratory (RRL)
(Hyderabad)

(a) Project: IND/80/004

Title:	Coal Gasification Project
Executing agency:	UNIDO
UNDP grant:	SUS 1,185,818 (actual) SUS 1,101,006 (original)
Government of India grant:	32,500,000 rupees
Project initiated:	10 December 1980
Completion date:	31 December 1984
Extended to:	31 December 1985

(b) Background

India has large reserves of low-grade non-coking coal. These reserves are estimated at 158.5 million metric tons up to a depth of only 1,200 metres and in seams thicker than 1.2 metres. As part of the country's R and D programme on utilization of low-grade coal, the Regional Research Laboratory at Hyderabad (RRL-H) was commissioned in the late 1960s to undertake research in this area. For over two decades now, it has been studying various aspects of gasification of coal. The Laboratory acquired a pilot plant for complete gasification of coal from abroad in 1966. It also procured a Linde air separator plant in the same year, as well as a boiler to generate steam at pressures up to 35 bar, and at temperatures up to 400°Celsius. Soon after the acquisition of this equipment, research interest in coal gasification technology completely faded away. Consequently, the equipment was not installed for the next decade and a half.

With the rise in the price of petroleum during the late 1970s and foreign exchange shortages faced by the economy, the Government, in 1979, again decided to revive development of coal-gasification technology. The basic equipment was erected by RRL staff themselves following drawings provided in 1966 by the foreign suppliers. While this generated substantial learning opportunities among RRL personnel, it did not permit the Laboratory to make use of the latest technology as embodied in new machines and analytical equipment which had subsequently become available. The United Nations' assistance was sought primarily to meet this specific need for importing the latest equipment (e.g. mass spectro-meter, computer-based gas chromotograph, etc.) and training the RRL scientists in its use.

The project's main objective was to develop proper technologies for effective utilization of coal reserves in the production of gaseous fuel used in the industrial and domestic sectors and also for power generation as well as to commission a pilot plant for moving-bed gasification of coal under pressure; to study the gasification characteristics of regional coal; ensure optimization of the pilot plant with various kinds of coal from regional fields; generate kinetic data; develop a mathematical model for moving-bed gasification; and conduct bench-scale studies on catalyst screening for gas conversion.

(c) Project results

As a result of this project, RRL has accumulated sufficient learning to be in a position to transfer technical know-how for commercial application of gasification technology. Its pilot plant capacity is one metric ton per hour of coal throughput. The results obtained from the working of such a pilot-sized plant are not directly applicable to the installation of the large-scale gasification plants required for power generation. However, the commercial usefulness of this project is in the generation of data and information on chemical characteristics of coal and of gas composition. This information is vital to work on the design and commercial operation of full-scale plants. RRL has consequently teamed up with Bharat Heavy Electrical Limited (BHEL), the largest producer of power generating equipment, with a view to commercializing a power-generation plant of 30 to 40 megawatt capacity, which will operate using high-pressure moving-bed coal gasification technology.

Apart from directly transferable technical know-how, the project has also generated extensive learning among the RRL personnel in this field. As a result, substantial cost savings are expected if it is decided at some future time, depending on the cost of other sources of energy, to install a coal gasification plant for use either in electric power generation or in fuel gas production. About 12 catalysts have been developed and studied for gas conversion to low boiling olefic gases.

RRL claims that its pilot plant is the only facility available in the whole world for testing any coal under moving bed pressure gasification conditions. The laboratory is keen to use this facility to meet the needs of other countries and would co-operate on a revenue-earning consultancy basis. The pilot plant is consequently fully maintained and kept operational to undertake such tests when required. RRL also visualizes collaboration with other research laboratories under the CSIR for undertaking research projects.

More significantly, the Laboratory has been seeking to co-operate with the Indian Institute of Petroleum (Dehra Dun) to develop further alternate energy sources and contribute its learning on handling high ash-content coal in a moving-bed gasification process. RRL is also confident of being actively involved in the setting up of a demonstration plant of 100-150 megawatt capacity using an integrated gasification combined cycle (IGCC) technology. This method is becoming increasingly popular and does not add to environmental pollution. The laboratory is waiting for the Government's decision on taking up the IGCC project. RRL has also ventured into projects on carbonization which have come about as a direct result of the methods used for coal gasification. In 1986, it won a major contract for putting up a carbonization plant, bidding against international firms. RRL supplied the entire set of designs and enabled the client to reduce substantially costs during the installation of the plant.

Case no. 6:

Sheep and Wool Development Centre (SWDC)
(Srinagar)

(a) Project: IND/72/043

Executing agency:	FAO
Commencement date:	May 1976
Duration:	3 years Initial: 4 years, April 1980 Extension: May 1983
UNDP grant:	
Initial:	SUS 807,450
Revised:	SUS 1,377,019
Government of India grant:	
Initial:	3,890,600 rupees
Revised:	16,377,700 rupees

(b) Background

The long-range objective of the project was to assist the Government in its efforts to raise the incomes of the wool-weaving community through the introduction of improved utilization and marketing of the improved woollen products in both local and foreign markets.

At the time of formulating this project, in 1974, spinning, dyeing, weaving and finishing of woollen fabrics were being carried out with age-old traditional techniques with consequent problems regarding uniformity and quality of production. Use of better raw materials and introduction of improved techniques for scouring, dyeing, designing and finishing, as well as in marketing, were deemed essential to raise productivity in this sector and thereby the incomes of all who were involved in weaving, with indirect benefits accruing to the spinners. It was against this background that UNDP assistance was given for setting up a pilot wool-processing, development and training centre.

(c) Project results

The project helped establish a pilot centre for wool technology development and training, with larger capacities and better facilities for scouring and dyeing of wool and fabrics, as well as carding and spinning of wool. The Centre was equipped with laboratory facilities for development of dyes and testing of wool yarn and fabrics. Several officers, extension workers and master craftsmen were also further trained in their respective fields under this project.

The primary function of the project was to set up an institution and, as such, no commercializable R and D was envisaged. There was a possibility of acquiring special know-how in the installation and operation of such an institution and transferring this knowledge to others. This was stated as one of the objectives. While the Centre has developed the necessary capability of assessing the feasibility of similar establishments in other states in India, it has not yet been called upon to render this service.

Case no. 7:

Bicycle Research and Development Centre (BRDC)
(Ludhiana)

(a) Project: IND/79/028

Title:	Research and Development Centre
Executing agency:	UNIDO
Commencement date:	August 1981
Duration:	Initial: 3 years (July 1984) Revised: 3-year extension
Completion date:	July 1987
UNDP grant:	Initial: $US 1,446,700 Revised: $US 1,550,401
Government of India grant:	7,836,602 rupees (in kind)

(b) Background

India is the fifth largest producer of bicycles in the world. Exports of bicycles and bicycle components represented approximately 4 per cent of the entire engineering goods exports from India. Nevertheless, this constitutes only a small proportion of total world trade in this sector. In order to increase the country's share of the world bicycle market, more emphasis on design development, quality control and diversification of products would be necessary.

The Indian bicycle manufacturing industry has faced a sellers' market since its inception in 1938. Consequently, little effort has been put into improving the basic design and quality of the product, or in introducing modern production techniques and new lightweight sports and excercise models.

The gradual saturation of the domestic market, as well as stagnation of imports by the developed countries, has gradually been compelling the Indian industry to introduce modernization. Not only from the point of view of the industry as a foreign exchange earner, but also because it is in the small-scale sector, directly employing about one million workers, with another 20,000 or more employed in servicing, repair and sales sectors, the Government decided to give a boost to the bicycle industry by setting up a research and development centre for the modernization of the bicycle industry. This R and D is intended to enable the industry to meet more effectively the internal and export market demands for new types of bicycles and components.

(c) Project results

Despite initial delays, the work of the project is being well implemented. Within the project, the following tasks have been undertaken: the designing of multi-speed chain wheel and drive systems; over 200 drawings pertaining to various bicycle components; design of folding bicycles; basic design concepts of lightweight bicycles including specification of components. The project has not yet been completed, but there is ample evidence that the Centre has taken significant steps in R and D work, innovating and improving upon the design models and diversifying into new products. In order to keep up with international standards, bicycle and component samples from

other countries have been examined in detail.

The Centre has just begun transferring its acquired know-how to local industry. It has received about 200 enquiries from small-scale industries and executed about 80 orders in its laboratories. The Centre has also undertaken the basic design concept of a lightweight bicycle.

Case no. 8:

Instruments Design Developments and Facilities Centre (IDDC)
(Ambala)

(a) Project: IND/79/046

Primary function:	Building of R and D capabilities
Executing agency:	UNIDO
UNDP grant:	SUS 1,927,700
Government of India grant:	12,150,000 rupees
Final evaluation:	30 September 1985

(b) Background

Scientific and electronics instruments and the related industry at Ambala date back 100 years. The entire industry, which is concentrated in small-scale units, employed about 6,000 workers in about 400 units in 1980. The industry produces goods worth 60 million rupees per year. With its historically evolved prominent position, Ambala was expected to play a major role in further development of the electronics industry in the province of Haryana. As a result, the Government of Haryana established the Haryana State Electronics Development Corporation Limited (HARTRON). The Instruments Design and Development and Facilities Centre (IDDC) was set up in June 1981 at Ambala, under the aegis of HARTRON.

The objective of establishing IDDC was to contribute to upgrading the quality and assuring the expansion of production of scientific instruments by the small-scale industrial units in Ambala. Given the available entrepreneurship and investment potential of the instrumentation industry at Ambala, IDDC was to evolve into a National Centre for design and development of instruments, involving medium level technological sophistication. The industry was expected to increase its output from 60 million rupees to 250 million rupees and to expand employment from 6,000 to 20,000 workers. The erstwhile Quality Marking Centre, which provided a quality assurance service to the small-scale industry, was merged with the IDDC.

IDDC was established as a multi-service centre to provide a range of design, development services and training to the scientific instruments and electronics industries at the cottage and small-scale level. To achieve this objective, a UNDP grant and Government of India counterpart funds were devoted to constructing a building in which to house the IDDC laboratories and technical units and equip them adequately with measuring and testing instruments.

The original UNDP grant was for SUS 960,000; the project duration foreseen was two and a half years. The first mid-term project review recommended an extension of one year, up to December 1984. It also recommended an additional UNDP allocation of SUS 332,000 to the initial project cost which, owing to price escalation, had already increased to SUS 1,195,700. The second review recommended another extension of one year up to the end of 1985 with additional UNDP inputs of SUS 400,000. Both these recommendations were accepted, taking the total UNDP allocation to SUS 1,927,000 and the project completion period to four years and six months.

(c) Project results

One cell of IDDC has been established as the Electronic Research and Development Centre (ERDC) at Gurgaon. This cell started functioning in 1984 and rendered design services to the local industry. IDDC itself has four major facilities for designing and developing electronics, optical and electromechanical instruments and for undertaking specialized electroplating jobs. It also has an electro-medical laboratory and a final testing and environmental testing laboratory. Moreover, it has a training and technical information unit which is devoted to raising the general level of skills in the region. The Centre obtains its feedback through regular meetings with industry in end-users' committees. An advisory board consisting of well-known industrialists, research scientists and professors reviews its activities once a year.

IDDC works on a non-profit basis, charging the actual costs as fees for developing the required instruments for the local industry. Its electronics design and development laboratory has so far completed more than 35 projects and its quality marking and electro-plating services are widely utilized by the industry in the region. It has served more than 407 users since its establishment in 1984. It enrols corporate members for a nominal fee of 100 rupees per annum. These become regular clients and serve to propogate IDDC's capabilities and provide the much needed feedback to the Centre. More important perhaps is its achievement in developing 75 products as required by the sponsoring firms. Some of these sponsoring firms are large engineering manufacturers such as Swaraj Mazda, who use IDDC to develop prototypes for components currently being imported. The majority of firms for which products have been developed are in the small-scale and ancillary sector. IDDC engineers have also developed some basic educational electronics kits and software packages which are currently being commercialized. The strength of the Centre appears to be in its ability to redesign and adapt certain imported products to meet technical specifications and input availability in India. It also maintains close working links with similar organizations in the country. The Centre has recently completed four important projects which, its members expect, will have wide-ranging commercialization prospects. These projects are (i) Design and development of an electronic clock with a temperature meter for LED display in offices and commercial enterprisess; (ii) Teaching robot; (iii) Polishing of lenses; (iv) Installation of a mini-computer at IDDC. The Centre already takes up such commercial jobs as the preparation of monthly electricity bills for the electricity authority, etc. Its potential is linked to progress with computerization in the province.

Case no. 9:

Central Electronic Engineering Research Institute (CEERI)
(Pilani)

(a) Project: IND/72/047

Title:	Advanced technology in semi-conductor devices
Executing agency:	UNESCO
Commencement date:	November 1976 (project submitted in June 1974)
Duration:	5 years (project completed in September 1981)
UNDP grant:	
Initial:	SUS 921,524
Actual:	SUS 2,280,333
Government of India grant:	
Initial:	SUS 96,750,000
Actual:	Rs. 18,223,000

(b) Background

The domestic demand for electronic goods in India using semi-conductor devices was projected at Rs. 800 million by 1983-1984. The project, formulated in 1974, was intended to reduce the lead time in providing required devices to the industry by creating an adequate R and D base in the field of semi-conductor technology which would serve the needs of an expanding industry.

Assistance sought for microwave transistors, integrated circuit models and microwave diodes. The main requirements dealt with the exchange of experts and training; expansion of CEERI's facility for research and development leading up to batch fabrication of semi-conductor devices and for the development of devices required for integrated circuit television sets. These selected areas were in line with national priorities.

The main effort during the project was directed at the process whereby raw wafer is converted into a finished chip ready for encapsulation through the fabrication of devices on the wafer. This stage involves the use of the most sophisticated processes and technology. It should be pointed out that the project itself, from its inception, sought to establish strong links with industry both at the input end, in terms of the making of masks, and the output end, in terms of encapsulation of devices fabricated at CEERI.

(c) Project results

The project has been evaluated as part of UNDP's Selected Project Intensive Review Exercise (SPIRE). It was characterized as a successful project in this evaluation because of (i) its representative nature for the India Country Programme, in that it dealt with sophisticated technology; (ii) the ability of the project to meet changing needs; (iii) good tripartite co-operation and (iv) its successful linkage with the final users of its results. The project, it was concluded, had already "paid off" in the application sense.

CEERI was able to license its know-how to various manufacturers for industrial use and large-scale production. It was able to do so because it developed the capability to extend the development of a model device to its prototype stage and then on to the next stage of incorporating features for industrial use. As a result, the following products were licensed to the industry:

	Object of licence	*No. of parties*	*Expected annual turnover (rupees)*
1.	Transistor and diodes	1	20 million
2.	Semi-conductor packages	6	7 million
3.	Four point resistivity probe	1	25,000
4.	Laminar flow clean	1	500,000
5.	Photoresist spinner	1	25,000

Another major project for which know-how was passed on to the industry is the excitation

control system for diesel electric locomotives. Know-how for this was developed with a sponsorship from Bharat Heavy Electricals Limited, a public-sector enterprise. Thus, the project enabled CEERI to achieve commercializable output as four of the five products which it has licensed have directly benefitted from the activities developed under the United Nations system-funded project. CEERI undertook 18 other sponsored projects during the tenure of this project, including one from the Indian Space Research Organization (ISRO) for continuous supplies of hybrid integrated circuits - a highly complex area of advanced semi-conductor technology. Private enterprises also called on CEERI for similar expertise and were forthcoming with sponsorship. It transferred know-how for colour television to the Electronics Corporation of India. UNESCO and COSTED have expressed interest in utilizing CEERI as a regional centre for promoting technology transfer to developing countries of the region.

This project has been characterized by an initial objective of developing CEERI user links. It has already yielded substantial commercial benefits. Further success in this regard will depend upon: (i) building up of institutional linkages between such high technology projects and all other relevant (complementary and user) organizations; (ii) systematic machinery being built into the project for upscaling of the technology from the laboratory to pilot and demonstration stages, so that new processes and products developed in the project may quickly find their way to commercial production; and (iii) benefits to CEERI from commercialization of its results. Although this has been achieved to some extent in this project, the process could be further improved.

The project, its nature and results had prompted the evaluation team to make an explicit recommendation for upscaling of the technology, as in (ii) above. To this extent, the commercialization achievement and potential of the project have been significant.

Case no. 10:

Institute for Design of Electrical Measuring Instruments (IDEMI)
(Bombay)

(a) Project: IND/82/002

Title:	Evaluation and Product-*cum*-Process Development Centre at IDEMI
Executing agency:	UNIDO
UNDP grant:	Initial: SUS 721,400 Final: SUS 1,208,800
Government of India grant:	Initial: 5,271,370 rupees Final: 9,353,000 rupees
Completion date:	Originally December 1985 (December 1982-December 1985) extended up to December 1986

(b) Background

IDEMI was established in 1969 and from its inception was supported by a fund from the United Nations system under the first project whose duration was from 1970 to 1974/1975. The Institute is under the control of the Department of Small-Scale Industries of the Central Government. The Institute was established to remove some of the technological constraints faced by small-scale industries. These constraints have been especially severe in relation to design development, evaluation of new products, as well as quality control of existing production. Small-scale instrument manufacturing industry, located in and around Bombay, could neither afford the vital test equipment nor acquire the technical skills required for these critical activities. IDEMI was

expected to fill these needs.

The Institute, after closely assessing the industry's requirements during the decade of its existence, identified the areas in which further capabilities needed to be built up. Given the need to develop facilities for design, testing calibration and evaluation of electronic process controls and low-cost instruments, IDEMI submitted the proposal to the Government of India for further United Nations support. This proposal was approved in the latter half of 1982.

The second project (IND/82/002) was designed to promote import substitution and export promotion of electrical, electronic and process control instruments and appliances manufactured by small-scale industries.

More than 75 per cent of funds ($US 773,340) was spent on acquisition of equipment. This equipment was procured with the objective of: (i) establishing reliable evaluation (quality assurance) facilities for a range of electronics and pneumatic process control instruments. These evaluation capabilities were also to be used for testing new products and providing the operational feedback to small-scale units; (ii) development of standards for process instruments; (iii) strengthening of tool-room facilities for undertaking R and D on domestic and low-cost appliances and for substitution of scarce raw materials. The tool-room was also to be used for developing prototypes and specialized dyes and jigs for small-scale users; and (iv) building up a cadre of trainers.

(c) Project results

IDEMI did not confine itself to serving only small-scale industries. Its excellent tool-room and calibration facilities are also utilized by medium- and large-scale industries. However, of the 686 units to which IDEMI provided consultancy in 1983-1985, nearly 80 per cent were in the small-scale sector. The number of units serviced during 1987-1988 was 537, of which again a large majority was from the small-scale sector. The Institute provided a total of 979 services (jobs undertaken) in 1982, 2,511 in 1985 and 3,400 during 1986. Revenues earned by IDEMI have shown an upward trend and rose to 5.14 million rupees in 1987-1988, from 3.96 million rupees in 1986-1987 and 3.71 million rupees in 1985-1986. IDEMI currently meets more than one-half of its recurring expenditure from internally generated revenues. It has set as its principal target to achieve financial self-sufficiency. This is laudable for an institution which essentially works on a non-profit basis. The Institute also organizes 12 regular training courses every year. Over the three years, i.e. 1985-1986 to 1987-1988, some 80 training programmes, including IDEMI's regular and tailor-made programmes, were organized with approximately 1,130 participants.

IDEMI has utilized the two United Nations projects, and especially the most recent one, to build up well-equipped laboratory facilities in 10 areas. These areas are electrical, electronic and process control instruments, tool design, testing and calibration of electronic instruments, flow measurement, testing of domestic appliances, testing of pneumatic elements, chemical machining, tool manufacture and training.

It maintains close liaison with the Bureau of Indian Standards and its senior staff serve on some of the standardization committees. The Bureau has entrusted IDEMI with formulation of new standards in process controls and electrical measurements. A compendia of eight standard proposals has been developed for a range of products and activities. Documentation of design manufacture and maintenance on more than a dozen instruments has been prepared; 13 prototypes, their know-how and technologies have been transferred to local industries. A comprehensive standardization proposal for quality control and safety of efficient household electrical appliances has also been prepared. The Institute's tool-room and mechanical workshop have undertaken a number of complex and challenging jobs for a diverse range of Indian clients. These have included development and manufacture of mechanical heart valves to photochemical machining of machine tool components. It continues to render support to the small-scale sector at fairly subsidized rates. Nor has its contribution to import substitution efforts by the medium- and large-scale industries been negligible. IDEMI has not so far undertaken any foreign assignments in other developing countries.

Case no. 11:

Ahmedabad Textile Industry's Research Association
(Ahmedabad)

(a) Project: IND/82/011

Title:	Application of Research Results in Easy-care Cotton Fabrics in the Textile Industry
Executing agency:	UNIDO
UNDP grant:	US$250,000
Government of India grant:	1.464 million rupees
Completion date:	December 1987 (extended by one year)
Final completion date:	December 1988

(b) Background

The project represents an example of how the United Nations system has provided an independent and substantial grant to enable a research institute to commercialize the results generated in an earlier project which was also funded by the United Nations system.

The UNDP had funded, in 1973, through project IND/72/035, the development of research capability in ATIRA in the area of finishing process technology for cotton fabrics. During that project, ATIRA received advanced technological know-how and equipment (e.g. an infra-red spectroscope, scanning electron microscope, etc.) which enabled it to carry out planned process and product development programmes - especially in the area of easy-care properties of cotton fabrics, soil release and flame retardancy. The equipment and training gave ATIRA the capability to generate experimental conditions, undertake precision measurements and interpret the results of experiments. During the course of the original research programme (IND/72/055), ATIRA was able to develop new resin catalysts, improve measuring techniques, develop superior fabric preparation technologies and controlled application of easy-care processes.

The project under review (IND/82/011) was initially proposed in 1978 by ATIRA scientists who clearly visualized the need for a follow-up stage to commercialize the results of the earlier project. The project was finally approved in 1982, commenced in December 1982 and more effectively, in September 1983, with the appointment of a Chief Technical Adviser. It was reviewed in 1985 and was given two extensions beyond its original completion date of December 1986.

The objective of the project was to introduce new chemical finishes at the commercial level which would upgrade the quality and utility of cotton fabrics, especially garments manufactured in India. More specifically, the objective of the project was to undertake the steps and activities required to transfer the results obtained during ATIRA laboratory research on easy-care cotton fabrics to the industry for commercial application. Mention should be made that ATIRA was registered in December 1947 following the initiative of leading Ahmedabad textile industrialists. It began its research activities in 1950. Since its very inception ATIRA has maintained a very close working relationship with industry. Its membership extends to 219 units which account for nearly 40 per cent of active spindles and more than 70 per cent of working looms in the country. ATIRA undertakes annually as many as 5,000 technical service assignments for the industry, earning an annual revenue of 0.6 million rupees.

(c) Project results

The work under the project did not exclusively cater for commercialization of earlier results. A part of the resources, both financial and human, were committed to the continuation and further refinement of laboratory research. This was focussed on four projects designed again to improve the techniques for and quality of fabric finishing.

The primary activities were nonetheless concentrated on commercializing easy-care processes. These could be divided into four stages: (a) preparatory work; (b) pilot-scale trials and mill trials; (c) wearer trial evaluation and selection; and (d) manufacturing fabrics and garment field trial.

The first three stages did not encounter any difficulties. Major problems, however, arose at the garment manufacturing and field trial stage. Field trial is a fairly expensive activity. ATIRA was not provided with any rupee funds for undertaking the manufacture of shirting and bed sheets from pre-selected finished fabrics. Neither was any financial allocation made to follow up the field trial over time. UNDP funds could not, according to existing Government rules, be converted to rupee allocation. As a result, ATIRA had to look for assistance from private industry which was not forthcoming owing to depressed conditions in the industry. It had to depend ultimately on the public sector National Textile Corporation (NTC). While the NTC agreed to manufacture the garments without charge, there were considerable delays. The field trial was effectively delayed by two years. Some of the information expected from NTC on performance of easy-care finished garments after repeated washes did not reach ATIRA. The trials undertaken at ATIRA were, however, completed and their results were analysed. This represented partial achievement of originally established objectives for the project. The non-availability of adequate rupee funds was principally responsible for this situation.

It is also clear that the market research, which was planned as part of the project, could not be undertaken by ATIRA. The Association had to depend upon other agencies but could not find dependable partners for this activity. It was asked to refer all its enquiries regarding domestic and export market potential to the Apparel Export Promotion Council (AEPC), a para-statal organization. AEPC, after an initial effort, did not provide ATIRA with any of the required information.

From the discussions at ATIRA, it is evident that because of the delay in launching and completing the field trials, the results have so far not been commercialized. Only recently has a major fabric manufacturer beginning to export garments commenced trial manufacturing of garments, using fabrics with an easy-care finish. If successful, this will be a major step towards proving the process for bulk volumes and commercializing it. Moreover, some training in the tailoring of easy-care fabrics and a wider dissemination of its benefits are also required for further commercialization.

Case no. 12:

Central Soil and Materials Research Station (CSMRS)
(New Delhi)

(a) Projects examined:

(i)	*IND/79/034*	Establishment of soil dynamics laboratory
(ii)	*IND/79/037*	Establishment of research and testing facilities for rockfill
(iii)	*IND/82/049*	Behaviour of concrete under T stresses
(iv)	*IND/82/052*	Facilities for research and testing in rock mechanics

(b) Background

The ultimate objective of all four projects was "to support the Government's efforts in exploiting the irrigation and hydropower potential of the country, particularly in the Himalayan region with extremely difficult and complex terrain conditions". This is to be achieved through upgrading of existing research, engineering design and consultancy capability of the Central Soil and Materials Research Station (CSMRS). The objective dovetails completely with India's development needs and aims. With the provision of state-of-the-art equipment and training of personnel, it was expected that a quantum leap in design and construction practices would be achieved. Greater efficiency and economy in implementation of irrigation and hydropower projects will eventually lessen dependence on foreign expertise. CSMRS, because of its locational proximity to Himalayan river projects and its position in the Government network, was selected for United Nations system assistance. Moreover, it was also thought to be "appropriate that a country such as India have its own capability for geotechnical exploration and material quality control, especially as it has served, and will continue to serve, as resource agency for the neighbouring part of the world in this rather critical area of irrigation and water management". Funds made available by the United Nations for these projects amounted to $US 6 million between 1980 and 1987.

(c) Project results

The overall purpose was the establishment of modern materials testing and geotechnical testing and research facilities. This was met despite some delays. The capability to use the equipment beneficially continues to be developed even after completion of United Nations support for the project. Some of the equipment has not been fully commissioned in the sense that its full potential is still not being exploited. The four projects cited above in part (a) have together created the most advanced laboratory for material and geotechnical testing in the region. Consequently, CSMRS is already playing a more prominent role in the geo-engineering profession. This has been achieved by:

(1) Organization of national and international workshops where visiting consultants give lectures and demonstrations;
(2) Extensive involvement with research organizations such as the civil engineering departments of Indian institutes of technology; undertaking of graduate courses and doctoral research;
(3) Increased professional involvement in water-resource management and geotechnical research.

Overall, the projects, though not yet completed, have created in CSMRS a vital resource which will act as a nucleus for growth in understanding the nature of hydraulic structures.

CSMRS has issued detailed estimates of monetary benefits derived from CSMRS activities in India, following the practice of its sister organization, namely, tje Central Water and Power Research Station. The volume of foreign exchange savings effected by the Station has also been estimated. These estimates are visibly over-optimistic but they nonetheless reflect a broad measure of benefits accrued from United Nations system support to projects in CSMRS.

Foreign exchange earnings have been calculated on the assumption that CSMRS services directly and fully substitute necessary inputs of foreign expertise. The number of person-days contributed by CSMRS experts are valued at rates earned by Water and Power Consulting Services (WAPCOS - the commercial wing of the Central Water Commission and Ministry of Water Resources) from foreign clients. According to CSMRS, foreign exchange earned/saved to the end of 1987 was $US 1,699,000.

The institution has also claimed a net saving of 10,775.4 million rupees through services rendered on indigenous projects. Of this, 7,096.4 million rupees were saved on projects already completed or under construction. These savings arise from reductions in material costs, lower costs of excavation and of labour inputs etc. as a result of advice from CSMRS. Table 1 in annex I provides details of the headings under which savings were generated in 15 completed projects undertaken successfully by CSMRS.

CSMRS has been selected by some developed country firms for consultancy work on projects being implemented in South and South-East Asian countries (see table 2 of annex I). Its experts have also been serving as advisors on irrigation projects in various developing countries. CMSRS is currently competing successfully with foreign firms for projects in this region. It also provides services to other Indian consulting and engineering firms working in the area of geotechnology and materials testing.

One recommendation stressed by the team of experts who undertook the evaluation of the projects was the need to assure that adequate resources were available in order to continue the work initiated during United Nations support for the projects. These resources have to be provided by the host country Government. The second recommendation was to put in place the required experts and personnel prior to the execution of the project and the arrival of sophisticated equipment. Some equipment has remained unused, as the required professionals were no longer available. Thirdly, necessary accessories and complementary equipment required for the efficient functioning of equipment was not available locally. This lack likewise resulted in delays and under-utilization of imported equipment. Finally, it should be added that major benefits and commercialization possibilities will emerge in future years as up to the end of 1988 the facilities were still being installed.

Case no. 13:

Central Leather Research Institute (CLRI)
(Madras)

(a) Project: IND/77/012

Title:	Demonstration Centre for Processing of Slaughterhouse By-products
Awarded to:	Central Leather Research Institute
Executing agency:	FAO
Commencement date:	April 1979
Duration:	5 years, i.e. up to December 1984
UNDP contribution:	SUS 250,000

(b) Background

India has the largest cattle population in the world - some 40 million animals including cattle, buffalo, sheep and goats are reportedly slaughtered annually in about 8,000 municipal slaughterhouses across the country. There is also considerable slaughter outside the municipal slaughterhouses. Conditions in these slaughterhouses are deplorable and most lack even minimal facilities; this is partially responsible for a total waste of all by-products of the slaughter houses. Moreover, there were no commercially viable and proven technologies available in the country for suitable utilization of these by-products. Meanwhile, the country has been importing a substantial volume of animal-based products to meet domestic requirements. Proper utilization of slaughterhouse by-products could yield substantial foreign exchange savings through import substitution and also eventually generate export earnings in subsequent stages.

The project was designed to maximize the economic return per animal by optimal utilization of slaughterhouse by-products. This utilization would generate value-added products, both for the domestic and export markets. The project was thus expected to contribute directly to the economy and also to the saving and earning of foreign exchange. Its importance lay also in the improvement of working conditions for the primary producers and in reducing environmental pollution.

(c) Project results

Two collagen-based products were developed, namely collagen tube and collagen sheet. Of these, collagen sheet has been found useful as a temporary biological cover on open-skin surfaces of all descriptions. Dressing the surface with collagen sheet prevents air-borne infection and flow of fluids. It also helps in proper granulation of the damaged surface resulting in a soft and supple healed surface with minimal scar formation. Its use has been clinically proven in more than 600 cases of burns, traumatic wounds, amputated surfaces, graft donor sites, etc. It is also more economical than other conventional materials in use. Other products developed over the duration of the project were:

- Soluble collagen as a base material for cosmetics such as shampoo and moisturizer;
- Protein hydrolysate from tannery chrome shavings, for use in sizing of paper, manufacture of safety match boxes and adhesive for joining work;
- Cattle feed supplements in the form of protein meal;
- Keratin hydrolysate from poultry feathers;
- Pet foods and pet treats;
- Glue from chrome-tanned leather wastes;
- Cattle casings which are odourless and stronger, and
- Sports goods.

The project has effectively enabled CLRI to establish a pilot plant with all the necessary equipment to process and utilize slaughterhouse by-products. Once these facilities have been established, they will continue to be used for proving the technical as well as commercial viability of a number of by-products developed at the laboratory. The pilot plant facilities were reportedly also used, as in some other projects supported by the United Nations system, for undertaking low volume job work on a commercial basis.

The know-how provided during the project through the visits of international experts has helped in the development of new products at the Institute. It has minimized the time required for the development of these products and also contributed to the adaptation of processes at the pilot plant level to the prevailing conditions in India. The exposure of Indian scientists and technical staff to conditions prevalent in other countries and to practices followed elsewhere has also helped in this process of technology transfer.

CLRI had faced the problem of non-acceptability of products developed by it early in the life of the project. As a result, a substantive component of heightening awareness, marketing strategies and identification of potential recipients of these technologies was included in the project at the time of a review meeting in November 1983. The Institute has since then organized a number of training programmes, seminars and workshops to make others aware of its by-products and increase their acceptability. Its staff has continuously interacted with the research and clinical facilities of some hospitals and medical colleges in Madras and the nearby region. As a result, a number of research projects have demonstrated the success of these products in treatment. Moreover, the Institute has also held numerous workshops with industry representatives to improve their understanding of the commercial viability of these products.

The Institute's success in commercialization of its results has been at best mixed, despite the considerable efforts undertaken in this regard. This situation is almost entirely owing to social attitudes which are resistant to accepting these products in daily use. Another reason is the lack of positive interest on the part of big drug and pharmaceutical companies which stand to lose their established business in conventional materials.

The Institute has received a licence to produce 3,000 collagen sheets per month for supply to leprosy hospitals. The Ministry of Health has also offered its help in encouraging the manufacture of these sheets in a commercial manner. The National Research Development Corporation (NRDC) is also making some funds available for better commercialization of the by-products. It appears that as a result of a workshop on by-product utilization, held in March 1989, the Institute may have been successful in evoking some interest from two of the larger manufacturers of surgical aids in the country, one of which is a multinational enterprise. The actual success of the project may only become evident when the products, technologies and processes developed by the Institute

through this project are adopted by a commercial undertaking for large-scale manufacture.

Chapter III

Utilization and commercialization of R and D results: selected issues and modalities for improvement

A. The experience of the R and D institutions participating in United Nations-funded projects

The experience of the National Geological Research Institute (NGRI) provides insight into one of the most pressing problems faced by science-intensive R and D institutions in the commercialization of their R and D results. Problems arise from a lack of clarity about the ownership of and responsibility for acquiring industrial property rights over the R and D results generated from United Nations system-funded projects undertaken at particular research institutions. NGRI developed an electronic sensor as part of its United Nations system-funded project on developing advanced geophysical methodologies. This instrument was further developed, tested and successfully used by NGRI in the second follow-up project, also sponsored by UNDP. The instrument embodied more advanced technology than was reportedly available either in developed or developing countries. As a result, a number of manufacturers approached NGRI seeking to acquire know-how and manufacturing rights. Owing to a lack of clarity on ownership and patenting practices in UNDP-funded projects, NGRI could not transfer its know-how to any of the manufacturers. A commercialization opportunity was effectively lost. Later, NGRI scientists were dismayed to discover that a Canadian firm had commercially introduced an instrument with similar parameters and performance specifications to that developed by NGRI. The Geological Survey of India (GSI), one of the largest users of such seismic sensors, imported this instrument from Canada on account of resource availability under a bilateral aid project from that country. GSI had earlier used the NGRI instrument and declared it to be both appropriate for its needs and embodying state-of-the-art technology. The bilateral aid, however, permitted GSI to spend the resources only on imports from Canada.

NGRI had requested permission to apply for a patent on the instrument before transferring the know-how to a manufacturer. It was reported that after a lengthy correspondence with UNDP this permission was refused, primarily owing to a lack of clarity on ownership of proprietory rights. Moreover, at least in this case, UNDP also appeared unclear as to whether or not proprietory rights could be applied to results generated in R and D projects funded through the United Nations system.

The second problem relates to the definition and measurement of commercialization. Both at CWPRS and CSMRS this question had apparently caused some confusion among scientists and research personnel. The earlier discussion on different types of commercializable results from science-intensive projects may be recalled at this stage. Neither CWPRS nor CSMRS generates much basic or abstract R and D results. They have received extensive United Nations support to create advanced research facilities in their areas and use these to provide the required R and D support as a necessary input for the transfer of sophisticated technologies to projects undertaken either within India or in neighbouring countries. Commercialization then takes the form of effective utilization of these facilities by other users, and in the transfer of learning and know-how to these users. CWPRS and CSMRS claim that the entire value of services rendered, savings effected in project costs and the value of the consultancy provided should figure in the assessment of the true value of economic benefits derived from the R and D projects undertaken by them with United Nations' support. They further argue that their services and other inputs should be valued at comparable international prices, which their clients would have paid in such cases.

Commercialization may, according to one view, be measured by actual pecuniary transactions which the institutions enter into with their client, either in their own country or in other

countries. This would imply that only those fees or other costs actually charged by the institution for contracted services to the user should be used to evaluate the extent of commercialization. Social benefits and non-pecuniary positive externalities may be included in any evaluation of the institutions by their respective Governments. This comprehensive evaluation will then show the actual social worth of these institutions for the economy. For purposes of evaluating success in commercialization of United Nations system-funded R and D, however, the direct revenues earned by the institutions from the use of technological capabilities - human and physical (equipment) capabilities - built up through United Nations system-funded R and D projects would be an important element.[16] It may be pointed out that this problem of measuring the extent of commercialization exists for all three types of R and D activities and is in fact more acute in the case of R and D institutions.[17]

Another problem faced by science-intensive R and D institutions, as well as by the product-adaptive R and D institutions, arises from the mobility of their R and D personnel. As R and D projects near completion and commercializable results are beginning to be generated, R and D personnel are approached by private firms with the result that there is a type of brain-drain away from the R and D institutions. Often, R and D personnel leave the institution to establish their own commercial operations, using the results generated during the R and D project. In NGRI, four such cases were reported. In CSMRS, some of its technical staff, after being trained in the use of new equipment supplied as part of the United Nations project, left CSMRS and joined private consulting organizations. This mobility of trained personnel seemed to have had negative implications for potential commercialization for the R and D institutions, as the know-how, to a large extent, is embodied in human capital.

In addition, it would appear that science-intensive R and D institutions, more than all others, have little or no expertise in translating their R and D results into commercially applicable innovations. Even when they do possess such capability, as in the case of NGRI, they lack the skills to actually transfer the know-how to potential entrepreneurs. Further, apart from CWPRS, which emerged as a startling exception, all other institutions involved in executing the projects examined seemed relatively unconcerned about the need to market their capabilities, or at least to improve the information flow about their facilities to potential users within India and/or other developing countries. This general absence of interest requires attention; the required marketing or innovation skills and institutional mechanisms for commercialization of results will have to be developed. Effective steps should be taken to stimulate interest and to develop expertise in information dissemination. Actual transfer of know-how and results from the institutions to potential users is critical to the success of commercialization. Establishing such capabilities, whether within or outside individual institutions, would appear worthwhile in terms of returns on the investment.

In at least two cases, namely, ATIRA and CLRI, the full potential for commercialization which was evident could not be exploited by the institution on account of exogenous factors. The institutions apparently had no control over these factors as they related essentially to lack of response from the industry to results of the R and D projects. In the case of CLRI, the optimal utilization of slaughterhouse by-products, which was to contribute directly to the economy (value-added products, both for domestic and export markets), could not be met mainly for two reasons. The first was the location of the pilot project, in the South, where social attitudes are resistant to accepting slaughterhouse by-products in daily use. The second was the lack of interest on the part of drug and pharmaceutical firms which, not incidentially, stood to lose their established business in conventional materials.

As for ATIRA, although one of the main objectives of the project was to set in motion the transfer of the results obtained in its laboratory research on easy-care cotton fabrics to the industry for commercial application, the lack of adequate funds (in local currency) did not permit ATIRA to carry out field trials for nearly two years. Owing to this delay in launching the completion of field trials, the results have so far not yet been commercialized. To some extent RRL has also suffered on account of exogenous factors, as the completion of its project on coal gasification has depended on fluctuations in the price of petroleum and the consequent Government waxing and

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16 In this context of, "utilization" and "commercialization" are tending towards the same objective: use and exploitation of the R and D results. This wider approach allows for more flexibility to evaluate the success in commercialization of R and D results.

17 See also *The role of research and development institutes in technological innovation: a case-study of Sri Lanka*, Report by the UNCTAD secretariat, 1988 (UNCTAD/TT/98).

waning of interest in coal gasification technology at different times. At the time of writing, the results and equipment remained unutilized, as interest in coal gasification technology for generation of power had once again dwindled. Conversely, in the case of SIIL, the total non-acceptance by established ironmaking firms of its newly developed technology for producing sponge iron by using non-coking coal was a factor in the non-commercialization of its R and D work.

The response to these exogenous factors has varied from institution to institution. In the case of CLRI, the Institute has obtained a license to produce the collagen sheets itself and utilizes the equipment received through the project to generate revenue by undertaking commercial jobs. ATIRA sought assistance from public-sector textile firms, but with mixed results. SIIL approached UNDP and the Government for investment funds, which were used to establish a sponge iron plant of commercial scale where the process developed by SIIL for producing sponge iron using non-coking coals as reducing agents was tested. RRL has still to work out links with potential collaborators for greater utilization of its capabilities in coal gasification.

However, these responses by the institutions concerned were formulated only after the adverse impact of dependence on exogenous factors had been felt and the commercialization of results was in jeopardy. Another strategy, as suggested in UNDP's evaluation exercise, would be to ensure the involvement of the potential corporate users of the results, whether they are in the private or public sector, from the very inception of the project.[18] According to the evaluation document, future funding from UNDP could be used to put together projects or establish R and D institutions where the Government, the particular institution, its staff, and private industry could all be co-financers and thus be jointly responsible for the utilization of results of projects. This strategy would in effect imply making endogenous the factors which had hitherto remained exogenous to the project. Given the importance of active co-operation by potential users, this set of factors should be rendered endogenous as far as possible. The lesson learned is to use increasingly United Nations financial assistance as a catalyst bringing the three important actors, namely, the R and D institutions, Government and the potential users, together in an institutional framework for every project. This suggestion is in line with and reinforces the conclusion of the high-level committee which reviewed the working of the CSIR network in India.[19]

All five production-related R and D institutions encountered difficulty in raising sufficient resources to keep their equipment and knowledge technologically up-to-date. This resource scarcity has been seen by representatives of the R and D institutions as part of the problem associated with their working experience on projects funded by the United Nations system. Until recently, follow-up action was rarely taken by the United Nations agencies on projects executed by R and D institutions which had, at some stage, been financially supported through the United Nations system. After completion of the projects, the institutions remained technologically up-to-date for a short period only. This phenomenon has been encountered by a number of institutions at various stages. In IDDC and BRDC, for example, the United Nations system-funded R and D projects when implemented had created sophisticated, up-to-date hardware capability. Once these projects were completed, the two institutions were unable to build upon their acquired base owing to lack of financial resources. As a result, their ability to provide the required services to industry progressively declined. However, IDEMI and CWPRS, institutions which had the advantage of participating in successive projects run through the United Nations system, were able to upgrade and expand their capability in the areas required. Successive project funding reinforces benefits from the learning generated in the earlier phase and may prove to be more cost-efficient in the long run. In the absence of such upgrading, the facilities created during the initial phase remain underutilized which leads to rapid erosion of motivation among staff who find themselves redundant because they cannot undertake the kind of work which had attracted them to the R and D institution in the first place. There is more than one way to overcome this important constraint and this subject will be taken up in section B.

Another problem perpetually affecting these institutions is a lack of adequate information about their facilities and capabilities on the part of potential users. For example, details of capabilities available with IDEMI, BRDC and IDDC were known only to a restricted few enterprises in the vicinity of Bombay and the northern region, respectively. Enterprises located elsewhere had

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[18] See also *The role of R and D institutes in contributing to technological innovation: A synthesis report*. Report by the UNCTAD secretariat (UNCTAD/ITP/TEC/11).

[19] See *supra* footnote 12.

neither access to, nor even information about, their facilities. More significant, there was almost a total lack of information about their facilities/capabilities in other developing countries requiring similar expertise and technical capabilities - information which could have opened new alternative sources for such technical services often acquired from developed countries. According to the institutions examined, this type of information could be centralized with the UNDP Office for dissemination as required. This would also avert the creation of similar facilities which merely duplicate those already existing. Even if such duplication were deemed desirable on the grounds of meeting the national needs of individual countries, a central information exchange through a United Nations agency would help also in the transfer of learning and experience. This would contribute to greater efficiency and also perhaps lead to pecuniary savings both for the United Nations system and the countries concerned.

Finally, for projects involving sophisticated technology and corresponding R and D activity, it would appear essential that project proposals made, for example, to UNDP, be thoroughly reviewed and examined at the earliest stages. This review would preferably be undertaken by experts in the particular area of technology who would examine the project both from the point of view of technical merit as well as from their potential for the utilization and commercialization of its intended results. Often, as in the cases of RRL, BRDC and ATIRA, the review is postponed until the mid-term evaluation of the project, when it is often difficult to make the necessary changes without causing undue delays and cost overruns. As was pointed out in the UNDP evaluation exercise, in some cases, the absence of expert comments and review at the earliest stages has regrettably led to waste which could have been avoided; institutions continue to develop their proposals and UNDP to process them until they are at a fairly mature stage. If at that stage the project is not deemed feasible, the exercise had already implied considerable expenditure of efforts and resources which could have otherwise been more usefully employed. Thus, an expert opinion even at the stage of project idea or project profile could be a useful input.

The above discussion of problems faced by institutions in utilizing and commercializing the results of their R and D activities underlines the multifaceted nature of efforts to improve the commercialization of results generated from, or the utilization of capabilities built up in, R and D projects funded by the United Nations system. The problems and issues vary, depending on the type of R and D institution and the nature of the activity launched during the project. Given the complexities and dynamic nature of the issue, real success in the commercialization and/or utilization of results may largely depend upon establishing a capability for monitoring progress and providing the required inputs on a continuous basis.

B. New approaches adopted by UNDP in the Country Programme (CP)

It is worthwhile noting that UNDP, which co-ordinates the funding and monitoring of R and D programmes at the national level in recipient countries for other United Nations agencies, has itself been aware of the issue of better utilization of project outputs. As a result, the Office of the UNDP Resident Representative in New Delhi, which oversees one of the largest R and D country programmes co-ordinated by UNDP, had undertaken an intensive evaluation of performance as a part of the Third Country Programme (CP III) review exercise, which ended in 1989.[20] Lessons learned as a result of this evaluation have provided critical inputs into the formulation of the Fourth Country Programme (CP IV) being launched in 1990. Some of the findings and conclusions of this assessment will have a direct bearing on better utilization and commercialization of R and D results. A discussion of certain aspects follows.

There was consensus that UNDP assistance should be focused on those priority areas where tangible results could be foreseen. Obtaining maximum results and impact from UNDP assistance was also a matter of concern. This perhaps represented a shift, albeit slight, from using assistance

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20 An important volume of documentation has been prepared as part of this evaluation exercise. See (i) *Assessment of prior UDNP experience in India*, Parts I and II, May 1989, New Delhi; (ii) *Review of factors influencing the performance of UNDP projects: UNDP Third Country Programme Review*, February 1988, New Delhi; (iii) *Proceedings of UNDP Third Country Programme Review Meeting*, February 1989, New Delhi; (iv) *Background Paper: UNDP Third Country Programme Review*, February 1989, New Delhi; (v) *Advisory Note on the UNDP Fourth Country Programme in India*, July 1989.

to fill technology gaps in a broad range of areas, as had been the case in CP II and CP III. In the light of recent policy moves in India to give a greater role to the private corporate sector with regard to industrial activity and related R and D, the UNDP review has suggested that its financial assistance be used as a catalyst for establishing R and D institutions with the joint participation of Government and industry, or even to be run independently by industry itself. Assistance would be available for the initial period, with the assumption that the industry concerned would then take overall responsibility in due course. Even where joint management and control of R and D institutions did not yet exist, projects with R and D components designed for potential use in the industrial sector would be expected in future to be associated closely with the concerned industry and user group so as to ensure utilization/commercialization of results. This suggestion had emerged from a discussion of possible measures to increase the impact of UNDP-assisted projects on the efficiency and welfare in the economy. Another conclusion highlighted in this context was that project priority should be shifted away from the notion of "technological excellence" to that of "technological relevance", especially in the areas of agricultural and industrial research and development activities funded through the United Nations.

UNDP's examination of project performance under CP III brought out the fact that, in terms of effectiveness and impact, the programme implementation had produced mixed results.[21] It was not apparent in most cases what tangible impact could be seen in terms of increases in "production or productivity in the sector". This finding again pointed to the need for a greater focus on a systematic analysis of the key issues and problems in the sector in future programmes.[22] Arising from the evaluation, the Advisory Note for the Formulation of Fourth Country Programme Projects, prepared by the UNDP Resident Representative's Office in New Delhi, recommended a programmatic (sectoral) rather than a project-by-project approach for identification of projects and allocation of financial support. The evaluation underlined the importance of an in-depth analysis of sectoral issues in order to develop a framework within which to undertake project support. This was seen as a way to improve the effectiveness and impact of United Nations financial assistance to R and D projects. The Advisory Note also emphasized the need to enhance the productivity of existing facilities and to strengthen the institutions already in place, be they for industrial, agricultural or other sectors. As the Note unambiguously states: "....it seems logical to view the dissemination and application of technology as the primary objectives of CP IV. In other words, the bulk of UNDP assistance should be geared toward the utilization of newly transferred or newly developed technologies".[23] Its evaluation and firsthand experience, as summed up in this statement, indicates the importance now attached by the UNDP Office in India to greater utilization of facilities developed as a result of financial assistance provided through the United Nations system, and to a fuller exploitation of the commercial potential of R and D results generated thereby.

C. Towards improving the commercialization of R and D results emanating from United Nations system-funded projects in India

Some of the major problems faced by the institutions in the further commercialization of their R and D results, or in the greater utilization of their facilities, are discussed below. The measures to resolve them, as suggested here, draw lessons from the Indian experience with utilization and commericalization of United Nations system-funded R and D results, which as mentioned before, has been by far the largest and most diversified experience in the context of the United Nations involvement in funding and supporting R and D activities in developing countries.

The lessons derived from the experience of R and D institutions responsible (executing institutions) for the projects which have been examined help to identify certain results of United Nations system-funded projects for technological development in the beneficiary country. As presented in the previous chapter, these lessons have been derived from both field research and the

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21 See *Assessment of prior UNDP Exprience in India, op. cit.*, p. 37.

22 *Ibid.*, p. 38.

23 See *Advisory Note on the UNDP Fourth Country Programme in India, op. cit.*, p. 43.

comprehensive evaluation undertaken by UNDP at the end of CP III.

- As a general point to be made, since the commercialization/utilization of results from United Nations system-funded R and D projects in India have so far been mixed, there is room for improvement in the effectiveness of the assistance programme and its impact on the national system of science and technology.

- A second point is that the objective of the United Nations technical assistance programme could be changed fruitfully from "technological excellence" to "technological relevance", as this would shift the necessary emphasis towards commercialization and utilization of project results.

- United Nations system financial inputs could be devoted to efforts where they would be used as a catalyst to bring together the three actors involved, namely, the R and D institution, potential users (in industry, agriculture or other sectors) and the Government. This would render more endogenous the factors which determine the degree of success in utilization and commercialization of project results. This approach would also lead to a more important role being played by the private corporate sector in industrial R and D, an approach which would be in line with the recent policy changes in the country.

- Assistance in the field of R and D, whether financial or technical, should be provided within the framework of a sectoral programme rather than on a project-by-project basis. In anticipation of the forthcoming financial assistance, UNDP could undertake an in-depth analysis of the sectoral issues. This programmatic approach could yield greater benefits in terms of effectiveness and positive impact on technological capability generation.

- Both the field enquiry as well as UNDP's evaluation exercise point unambiguously towards a greater focus on building up existing strengths rather than spreading the financial allocations over a large, diversified range of activities. This suggestion, if implemented, would mark a shift from the policy hitherto followed where United Nations system allocations cover technological gaps in a wide range of activities. Greater concentration on institutions which may have been recipients of United Nations assistance in the past and on areas which are expected to yield tangible results would help optimize the usefulness of outputs funded by the United Nations.

- There should be a clear understanding of the processes protecting creation and ownership of intellectual property rights with regard to results generated by projects (partly or fully funded through the United Nations system. This understanding should probably be formalized within the UNDP and be explicitly stated in the project contract between the UNDP and the institution to which the assistance is allocated.

- There are various stages at which special inputs may be required from the United Nations system, in general, and the UNDP, in particular, so as to ensure a better performance concerning commercialization and utilization of results. These inputs can be required at the stage of project selection so as to identify successfully those proposals which have greater potential for commercialization. At the time of project completion, some provision needs to be made to draw out all the possibilities for commercialization or to develop the results in such a way as to permit their effective use. Once the project has been completed, attention needs to be given to more effectively disseminating the results and proving them at pilot plant scale where necessary.

- The final point is that the institutions, and especially the production-related R and D institutions, often face acute resource constraints in updating and expanding hardware and equipment facilities which have been built up during the course of the United Nations system-funded project. These constraints mean a steady erosion of their ability to service their industry's or constituency's needs. Quite often, owing to the non-availability of critical newly developed equipment, the existing facilities may also remain underutilized. As to whether assistance should be given for creating new institutions or in strengthening the existing ones, what is needed is that, in the case of production-related R and D institutions which have received United Nations assistance in the past, a review and assessment of their requirements should be carried out on a regular basis by the local UNDP Office, so that these institutions can continue their provision of services. Support tends to go towards technological capacity-building with a view to rendering service to technology users.

It should be added that, in India, the pre-condition for assuring greater commercialization and/or utilization of R and D results has already been created, particularly in the light of CP IV. This pre-condition is borne out in the change in UNDP's stance on the results generated from R and D projects, namely in the adoption of "dissemination and application of technology" as the central objective of CP IV. This emphasis on the utilization of R and D results effectively mirrors the concerns expressed by the High Level Committee which evaluated the performance of the CSIR's network of laboratories and R and D institutions. The Committee, headed by Shri Abid Hussain, stated that "the major failure (of the CSIR network) perhaps is its inability to transform scientific results in the laboratory into technologies for industrial production".[24] It is therefore a fortunate coincidence that the self-assessment, both by the Indian Government and UNDP, of their own past experience in the funding and performance of R and D programmes has focused on the need for better utilization and application of results. This coincidence, it is hoped, will provide the positive environment within which to implement specific modalities in response to the above-mentioned preoccupations.

For improving performance with respect to commercialization/utilization of R and D results, it would be useful to explore, at this stage, as an immediate measure, the possibility of establishing, either in the UNDP's Resident Representative's Office or in the relevant counterpart agency/department of the Government, but preferably jointly, an institutional capability for systematic contacts with the project counterpart R and D institutions to follow up R and D results so far generated.

Concerning important supportive institutional arrangements for improving the commercialization/utilization process of these specific R and D results, the following suggestions could be advanced. An expert capability could be established for a rigorous evaluation of commercialization possibilities, covering new projects at their earliest stages. The latter could be particularly useful for factor-substitutive types of R and D activities, where the nature of the results should be relatively easy to assess at the conception stage of the project. This capability would be accessible both to the United Nations agencies and also to the counterpart Government agency, namely, the Department of Economic Affairs, in the case of India. The establishment of this capability will minimize wasted efforts and resources on the part of both the proposing institution and UNDP. It would also reduce the chances of a misunderstanding arising between the R and D institution and the United Nations agencies. This capability could be created, either in the form of resident technical advisers within UNDP, or through direct access to required expertise in selected areas.

As for sophisticated technology projects or science-intensive R and D activities, which are by their very nature complex, resource-intensive and entail a degree of risk in relation to their results, some effective process could be designed, possibly outside UNDP and the network of institutions or agencies that are beneficiaries of United Nations financial support. An independent capability in the framework of the highest authority dealing with questions of science and technology planning could, for example, be established. This capability would play a crucial role in ensuring that a greater proportion of R and D results were commercially exploited through regular monitoring of progress and assuring the availability of the required input at the right time.

Another question calling for attention relates to the availability of information on technologies emanating from United Nations system-funded projects, as well as access to these technologies. This information could also be available to other UNDP offices and would permit greater use of existing facilities as well as dissemination of the learning generated in specific cases, while avoiding unnecessary duplication. The importance of this question was emphasized by a number of institutions, particularly the production-related R and D institutions. This emphasis reflects two serious concerns. First, the extent to which such institutions' capabilities are utilized depends on dissemination of information to potential users. Secondly, such an information system needs to be upgraded and updated regularly. For this to work, UNDP and other relevant Government agencies would need to keep in touch regularly with the institutions which have received United Nations financial support. This interaction between the past recipients of United Nations agencies' support could be instrumental in resolving certain other issues as well.

Apart from these suggestions, the Indian experience also highlights the need to establish a

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[24] See GOI, *Report of the CSIR Review Committee..., op. cit.*, p. 2.

clear policy direction for the creation and appropriation of intellectual property rights over results which emerge from United Nations system-supported projects. There is a range of possibilities. There could be joint ownership by the United Nations and the relevant R and D institution (exclusively responsible, for example, for applying for the patent, and subsequently commercializing the invention), or sole ownership, either by one party under conditions specified by the United Nations. Where appropriate, contractual arrangements could also provide for payments of royalties and deal with questions of confidentiality. It might be useful to explore all these alternatives, as illustrated by the concerns of several institutions covered in this field research.

Finally, after the projects are officially terminated, it would be useful to organize regular periodic contact programmes with the institutions. These contacts could be linked to the updating of vital information through the mechanism suggested earlier; however, they should be undertaken even if the information system discussed above is not established.

These contact programmes will facilitate greater commercialization of United Nations system-funded R and D results in a number of ways. First, the institutions concerned would be encouraged to identify any gaps which may have been discovered after the official completion of the project. Certain gaps, if not addressed, might jeopardize the success of the entire project. Secondly, the United Nations agencies will benefit from the learning generated by these institutions in executing the projects. It should be emphasized that such learning is often institutionalized or organized well after the project has been officially completed. Thirdly, these regular contacts would enable the United Nations system to identify commercialization possibilities and suitably encourage the institutions to pursue them. Fourthly, this practice will contribute positively to the attainment of CP IV's objective of technological dissemination and utilization of results by placing a greater focus on existing institutions and strengths.

These suggested modalities have been derived from a review of actual experience of United Nations system-supported R and D projects. It is worth reiterating that, on a number of issues, the suggestions made here are reinforced by UNCTAD's work on technological innovation and the role of R and D institutions, as well as by the conclusions emerging from UNDP's own evaluation. It may be useful to implement some of these suggestions on an experimental basis, as part of a project to improve the commercialization and utilization of R and D results generated from United Nations system-supported projects in India. Such a project, if carefully formulated and implemented over an adequate time period, could yield extremely relevant lessons for the United Nations system's operational activities for strengthening the technological capacity of developing countries, for coping with the challenges and opportunities for their development and trade prospects arising from rapid technological change.

ANNEX I

Table 1

Central Water and Power Research Station

Project	*Period*	*UN contribution ($US)*		*Government of India contribution (Rupees)*	
IND/71/601	1972-1981	Total	3,715,335	Total	15,357,800
		Equipment	2,848,123	Building	8,150,000
		Consultants	481,861	Staff	2,077,000
		Fellowship	224,957	Equipment	2,534,000
IND/75/020	1977-1984	Total	2,721,457	Total	6,387,875
		Equipment	2,215,874	Building	3,079,785
		Consultants	180,719	Staff	1,747,710
		Fellowship	273,917	Equipment	331,388
IND/73/043	1977-1984	Total	1,604,161	Total	3,611,957
		Equipment	1,176,212	Building	332,036
		Consultants	131,030	Staff	1,587,620
		Fellowship	239,742	Equipment	680,000
IND/73/041	1977-1984	Total	2,298,949	Total	7,980,841
		Equipment	1,713,516	Building	2,252,000
		Consultants	265,114	Staff	3,856,000
		Fellowship	479,600	Equipment	1,660,000
IND/81/038	1982-	Total	4,145,400	Total	23,600,000
		Equipment	2,929,500	Building	6,703,600
		Consultants	533,000	Staff	5,350,070
		Fellowship	501,250	Equipment	16,703,600
IND/73/042 and IND/85/069		Total	1,956,044	Total	6,180,000
		Equipment	1,146,530	Building	2,180,000
		Consultants	219,368	Staff	1,183,000
		Fellowship	143,341	Equipment	2,817,000
		Subcontract	409,000		

ANNEX I

Table 2

Estimated benefit to water resources sector - CSMRS contribution in geomechanical and research investigation (Case study no. 1)

Completed projects

		Amount in Rupees (Crore) [a]
1.	Salal H E Project (J & K)	
(i)	Savings from reduced excavation of the ridge which provides the seat to spillway and power dam	14.67
(ii)	Savings from reduced quantity of concrete	33.00
(iii)	Savings from modified profile of the rockfill dam	4.00
(iv)	Savings from use of fly as (reduction in cement), use of local construction materials, escalation, etc.	32.50
		84.17
2.	Jakham dam project (Rajasthan)	
(i)	Savings in excavation for dam foundations	4.82
(ii)	Savings in concrete of equivalent amount	10.71
		15.53
3.	Maneri Bhali H E Project Stage-I (U.P.)	
(i)	Savings in the excavation of 8.5 km long tunnel - reduced section	14.98
(ii)	Saving in concrete of equivalent amount	33.30
		48.28
4.	Rihand dam project (U.P.)	
	Based on the instrumentation studies carried out by CSMRS, earnings on account of power generation (considering only 50 per cent extra)	65.70
		65.70
5.	Loktak project (Manipur)	
(i)	Instrumentation studies leading to preventive measures against landslide of power house	10.30
(ii)	Studies on open channel side slopes	9.63
		20.43
6.	Geophysical survey on project sites	
	Savings on account of reduced amount of drilling on:	
(i)	Chamera project	
(ii)	Sahibi Nadi project (Haryana)	
		20.51
(iii)	Salal project (J & K)	
(iv)	Dul Hasti project (J & K)	
(v)	Rangit project (Sikkim)	

[a] Crore = 10 million (unit of measurement).

Table 2 (continued)

		Amount in Rupees (Crore)
7.	Thoubal project (Manipur) Savings on account of using excavated material from spillway for earthen dam	4.00
8.	Maili dam project (Punjab) Saving resulting from CSMRS findings and recommendations based on dispersive soil identification/test results	0.64
9.	Chakra dam project (Karnataka) Savings owing to modified profile based on CSMRS test results	39.60
10.	Savings on account of land reclamation measures suggested by CSMRS	28.00
11.	Savings owing to reduced evaporation of reservoirs (i) Badkal Lake (Haryana) (ii) Maota (Rajasthan) (iii) Sagar (Rajasthan) (iv) Takhta Sagar (A.P.)	0.20
12.	Savings owing to reduced quantity of cement - use of pozzolona (i) Tidi dam project (ii) Tawa dam project (MP) (iii) Barna project (MP)	3.20
13.	Gunati project (Tripura) Savings with use of brick concrete instead of transporting conventional concrete from far-off places	1.17
14.	Chukha project (Bhutan) Savings resulting from use of micaceous sand, and saving in time of construction, escalation, etc.	40.88
15.	Badarpur thermal power project (Delhi) Quality control and saving owing to use of local material	2.5

ANNEX I

Table 3

Estimated benefit to water resources sector - CMRS contribution to geomechanical and research investigation (Case study no. 1)

Overseas projects - completed

	Country		*Project*	*US dollars*
1.	Afghanistan	(i)	Salma dam project	164,000
		(ii)	Quaza dam project	50,000
		(iii)	Kundus project	45,000
		(iv)	Alchin-Khanabad project	6,000
		(v)	Training of personnel	240,000
		(vi)	Bamiyan project	6,000
		(vii)	Charde Ghorband	25,000
2.	Algeria		Ouled Mellouk dam project	250,000
3.	Bhutan	(i)	Tangribi project	2,000
		(ii)	Chukha project	150,000
4.	Myanmar	(i)	Sedawagyi project	2,000
		(ii)	Pugyi project	160,000
		(iii)	Training of personnel	120,000
5.	Islamic Republic of Iran		Training of personnel	75,000
6.	Iraq		Training of personnel	75,000
7.	Nepal	(i)	Mahendra highway	1,000
		(ii)	Trisuli barrage	20,000
		(iii)	Training of personnel	20,000
8.	Philippines		Training of personnel	150,000
9.	Sri Lanka	(i)	Training of personnel	120,000
		(ii)	Setting up of laboratory	70,000
10.	Viet Nam		Training of personnel	240,000
				2,069,000

ANNEX II

List of institutions visited

1.	Regional Research Laboratory	Hyderabad
2.	Sponge Iron India Limited	Hyderabad
3.	National Geophysical Research Institute	Hyderabad
4.	Central Leather Research Institute	Madras
5.	Ahmedabad Textile Industries Research Association	Ahmedabad
6.	Institute for Design of Electrical Measuring Instruments	Bombay
7.	Central Water and Power Research Station	Khadakwasla/Pune
8.	Central Soil and Materials Research Station	New Delhi
9.	Pyrites Phosphates and Chemicals Limited	New Delhi
10.	Bicycle and Sewing Machine Research and Development Centre	Ludhiana
11.	Haryana State Electronics Development Corp. Ltd.	Chandigarh
12.	Instruments Design Development and Facilities Centre	Ambala.

ANNEX III

List of persons met

1.	Dr. A.V. Rama Rao	Director, RRL, Hyderabad
2.	Dr. Madhav R. Ghate	RRL, Hyderabad
3.	Dr. R. Vaidyeswaran	RRL, Hyderabad
4.	Dr. M.S. Mukherjee	RRL, Hyderabad
5.	Dr. D. Gupta Sarma	Project Director, NGRI, Hyderabad
6.	Dr. D.S.M. Murthy	NGRI, Hyderabad
7.	Mr. A.V. Ramana Rao	NGRI, Hyderabad
8.	Mr. K.P. Patnaik	Sponge Iron India Ltd., Hyderabad
9.	Mr. Muralidhar Rao	CLRI, Madras
10.	Dr. C.S. Rao	ATIRA, Ahmedabad
11.	Dr. J.R. Modi	ATIRA, Ahmedabad
12.	Dr. T. Radhakrishnan	Director, ATIRA, Ahmedabad
13.	Dr. P.K. Krishnamurthi	Director, IDEMI, Bombay
14.	Mr. M. Ramachandran	IDEMI, Bombay
15.	Mr. Ramani	IDEMI, Bombay
16.	Dr. Z.S. Tarporewala	Director, CWPRS, Pune
17.	Mrs. V.M. Bendre	CWPRS, Pune
18.	Mr. S.R. Gaikwad	CWPRS, Pune
19.	Mr. M. M. Kale	CWPRS, Pune
20.	Dr. C. Sudhindra	Director, CSMRS, New Delhi
21.	Dr. V.M. Sharma	CSMRS, New Delhi
22.	Mr. Ajai Kumar	IDDC, Ambala
23.	Mr. A. Sardana	IDDC, Ambala
24.	Mr. J.S. Radhawa	Director, BSMRDC, Ludhiana
25.	Mr. Harbans Singh	BSMRDC, Ludhiana
26.	Mr. J.S. Khorana	BSMRDC, Ludhiana
27.	Mr. A.K.P. Srivastava	PPCL, New Delhi
28.	Mr. G.T. Mirchandani	CEERI, Pilani
29.	Dr. W.S. Khokle	CEERI, Pilani
30.	Mr. Hamdy	Resident Representative, UNDP, New Delhi
31.	Mr. Matiul Islam	UNIDO Field Adviser, New Delhi

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